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MICROGRAPHIA NOVA:

OR, A NEW
TREATISE
ON THE
MICROSCOPE,
AND
MICROSCOPIC OBJECTS.

CONTAINING

I. The Description and Uſe of two different Reflecting Microscopes, of a new Form and Structure, and furniſh'd with a MICROMETER; *viz.* one deſign'd for the Pocket, the other mounted on a Ball and Socket, which renders it of *Univerſal Uſe.*

II. A large and particular Account of all Kinds of Microscopic Objects, to be found in the Human Body, in Quadrupedes, in Fowls, Fishes, Insects, Reptiles, *&c.* in Plants and Vegetables of every kind; in Earths, Minerals, and Fossil Substances; and various other *Miſcellaneous Subjects.*

With Directions how to procure and prepare them for Uſe; and divers occaſional Remarks interſperſed thro' the whole.

To which is added, An Account of the
Camera Obscura, and the Solar Microscope,
OR
Method of *Magnifying Objects* in a *Darken'd Chamber,*
In every Way by Reflection and Refraction.

By *BENJAMIN MARTIN.*

Psal. cxi. 2. גדלים מעשי יהוה דרושים לכל־חפציהם

READING,
Printed and Sold by J. Newbery and C. Micklewright, in the *Market-Place;*
R. Ware, in *Amen-Corner,* and T. Cooper, in *Pater-noſter-row, London;*
J. Fletcher, in the *Turl, Oxford;* W. Thurlbourn, in *Cambridge;*
and B. Collins, in *Saliſbury.* MDCC XLII.

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To His GRACE the

Duke of RICHMOND.

My LORD,

THE Uſefulneſs and Dignity of the Subject of the following Sheets are ſuperlative, and claim, on that Account, your Grace's Patronage. The Works of Creation, and the Means to diſplay them, are exactly in your Grace's Taſte; and cannot but be acceptable to the moſt refined

Philoſophical Genius. Providence has not only diſtinguiſhed you with a high Station in Life, but has made you capable to ennoble it by all the Qualifications of a PATRIOT and a MECÆNAS. Nor is your Grace's Character, as a VIRTUOSO, leſs conſpicuous; as every Gentleman can witneſs who has had the Honour of your Grace's Acquaintance, or a Seat in that Illuſtrious Society, of which your Grace is ſo diſtinguiſh'd a Member.

EVERY one who has been at *Goodwood*, is a Witneſs that your Grace has epitomized the larger and more ſurprizing Scenes of the Animal and Vegetable World, and erected, as it were in Miniature, a MUSEUM of *univerſal Nature*. All Nations, from *Lapland* to the remoteſt *Indies*, have paid Tribute of their choiceſt Product of *Beaſts*, *Birds*, and *Plants*, of every Tribe and Claſs, to the DUKE OF RICHMOND.

I CAN ſcarce forbear ſaying more —— but dwelling too long on Merit itſelf, is often irkſome, and I ſhould be afraid of offending no

Man

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Man ſo ſoon as your Grace in this Reſpect. I am ſure, MY LORD, if I know either myſelf or You, no Flattery has ſtain'd the Page; the mean Artifice of little Minds, who never fail to bewray their Stupidity to make their Patrons ridiculous. If I have ſpoke the Truth too far, 'tis owing to the fertile Theme. Vouchſafe to Accept and Patronize an Attempt to improve the moſt delicate and exquiſite of all our Senſes; and to diſcloſe ſome of thoſe inviſible Scenes of infinite Beauty, Perfection and Art, which lye unheeded, and recluſe from vulgar Eyes, in every Part of the Creation; I ſhall then promiſe myſelf auſpicious Succeſs. This Addreſs to Your GRACE can admit of no Apology; being but the Diſcharge of a Duty which Juſtice and Gratitude enjoin. The Meanneſs of the Author, or Manner of the Performance, can be no Objection, ſince every one knows, that, in Phyſical Matters, finite Quantities vaniſh when found connected with thoſe which are infinite.

I WISH Health (the Baſis of all ſublunary Bliſs) to Your GRACE and Noble FAMILY; and

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and am, with the ſincereſt and moſt profound Reſpect and Duty,

Your GRACE's

Moſt obedient

humble Servant,

B. Martin.

THE PREFACE.

AS the firſt Part of this Book is wholly employ'd in the Deſcription of the Parts and Structure of each new Microſcope here propoſed to Sale, 'tis needleſs to ſay any thing more in that Reſpect; I ſhall only add, that the Form is not only the moſt beautiful, elegant and convenient, but the Glaſſes in each Sort are the largeſt and beſt that can be made, and therefore the Perfection of theſe Microſcopes the greateſt that poſſibly can be. And that no Gentleman may be at a Loſs for an adequate Idea thereof, I have cauſed the Prints of them to be engraved as large as the Inſtruments themſelves are made. So that whether we regard the Novelty of the Form, the Improvement by the Micrometer, the Perfection of the Mechaniſm, or the Moderateneſs of the Price, I appeal to any competent and diſintereſted Judge, whether they do not excel any thing of this kind ever yet propoſed to the Publick.

I have oftentimes been requeſted by Gentlemen to give a Catalogue of Microſcopic Objects, which I have here done, and I preſume ſo compleat, that ſcarce any extraordinary Phænomenon, *which requires the Uſe of this Inſtrument, and within the Reach of a Perſon in private Life, will be found wanting in it. I could make a conſiderable*

conſiderable Apology for its being done in no better Manner; but 'tis ſufficient to let the Virtuoſo *know that it was wrote at a Time,*

Cum Sol non ſolito Lumine riſerit,
Et Fortuna volubilis
Fati difficilem jecerit Aleam.

Casim. *Lib.* I. *Od.* II.

THE Method of Magnifying Objects in the Camera Obſcura *is ſo curious a Subject, and ſo analogous to the Microſcope, that I believe the Reader will not think it foreign, to find a large and particular Account thereof added at the End of this Tract.*

I ſhall take my Leave of the Reader in the Words of that excellent Naturaliſt Ælian,

“ Notwithſtanding I well know there are extant the Lucubrations of other Men on this Subject, yet I fully perſuade myſelf, that the Subjects I have here collected together, and deliver'd in a familiar Style, will prove no vulgar Theme, a Treaſure not to be deſpiſed; and if it appears thus excellent to another, let him enjoy it; if not, let him leave it to be foſter'd and careſs'd by its Parent Author.

Præf. *ad Lib.* I. de Nat. Anim.

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CHAP.

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THE
Pocket Reflecting
Microſcope
With a Micrometer

BY

Benj: Martin

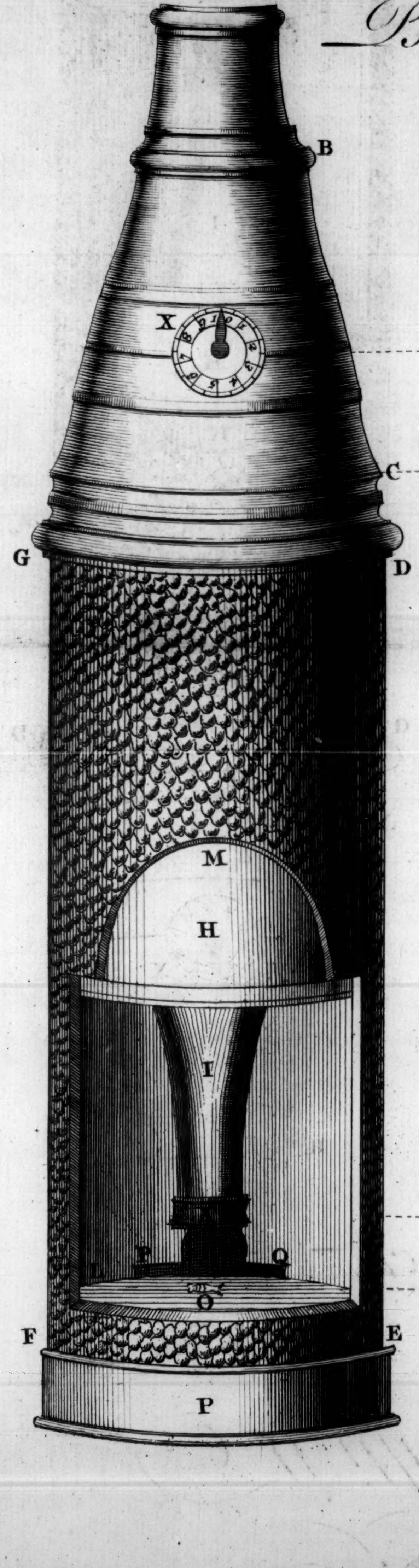


Fig. I.

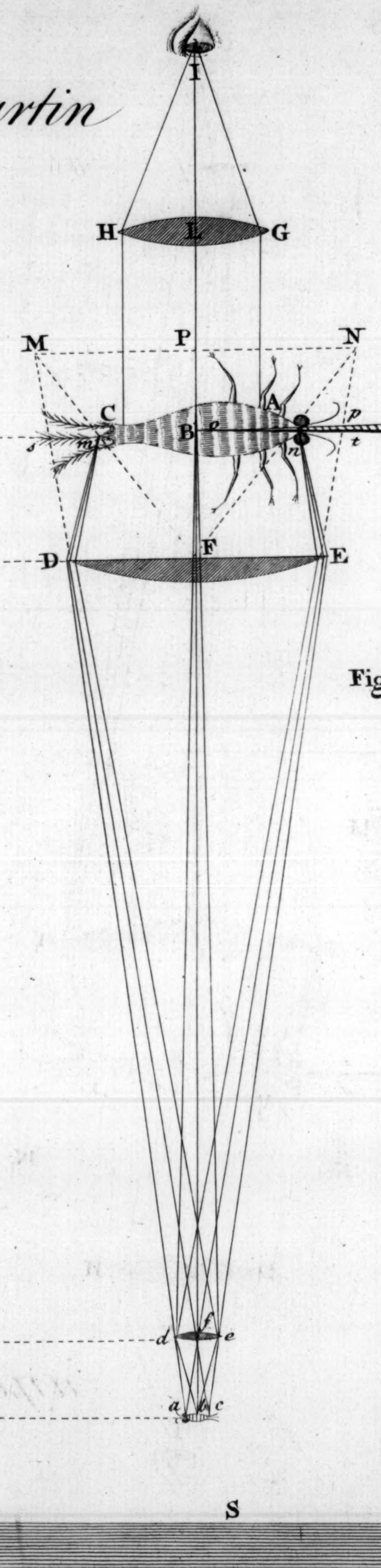
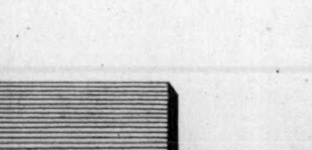


Fig: II.

These
Microſcopes
are Sold by
J. Newbery
Bookseller
in
Reading Berks.

Fig: III.



Eman: Bowen Sculp.

CHAP. I.

A Deſcription of the Pocket Reflecting Microſcope.

THIS Microſcope finiſh'd and fit for Uſe is repreſented in *Fig.* 1: It conſiſts of the following Parts, or Materials, *viz.* (1.) *Wood-Work*, containing the Glaſſes; (2.) Glaſſes, for magnifying Objects; (3.) A *Micrometer* for meaſuring ſmall Objects; (4.) *Tubes*, or *Caſes*, which makes the Body of the Inſtrument; (5.) A *Braſs Bottom*, containing a reflecting Mirrour; and is a proper *Baſis* for the Inſtrument to ſtand firmly upon. Of theſe I ſhall give a particular Account: And

Firſt, THE *Caſes* or *Tubes* which make the Body of the *Microſcope*, are two; (1.) The external Caſe DEFG, is made very ſubſtantial and ſtrong, lined with black Shagreen, or cover'd with Nurſa Skin, which is alſo very beautiful; (2.) The internal or inner Caſe, contains the *Wood-Work*, and moves within the other Caſe; Part thereof H is ſeen thro' the Aperture LMN cut in the outer Tube. Its farther Uſe will be hinted by and by.

THE *Wood-Work* conſiſts of ſeveral Parts or Pieces. As (1.) the Upper or Eye-Piece AB, which at B ſcrews into (2.) the Middle or Micrometer-Piece BC, which contains the upper Glaſs, the Micrometer, and the Image of the Object. This again at C ſcrews into (3.) the Piece C D, which contains the lower Eye-Glaſs, and is faſt glued into the upper Part of the internal Tube H. (4.) At the lower End of this moveable Tube, is glued in a round thin Piece, in the Center whereof is made to ſcrew (5.) the ſmall Pipe or Tube I; on the lower End of which ſcrews on (6.) the Button or little Cell K, which contains the Object Glaſs, and has a ſmall Perforation to admit a proper Degree of Light. Of theſe Buttons there are three to the larger Sort of *Microſcopes*, and two to the leſſer.

THE *Glaſſes* in the *Microſcope*, which ſerve to Viſion, are all Lenſes of the Convex Sort; and theſe of three different Magnitudes and focal Diſtances. As (1.) The upper Eye-Glaſs, whoſe Place is at B; and whoſe Size is repreſented (in *Fig*. 2.) at GH. Its focal Diſtance is about 1$\frac{1}{2}$ Inch. (2.) The lower Eye-Glaſs, which is placed at C, and repreſented at DE in *Fig*. 2. in its proper Size: It is ſometimes a double Convex; ſometimes a Plano-Convex, as there. (3.) The third Sort of Lens, is the Object-Lens contain'd in the Button K, and is repreſented at *de*, in *Fig*. 2. Of theſe there are three Sizes, as there is of focal Lengths, which are $\frac{1}{2}$, $\frac{3}{4}$, and 1 Inch.

THE other Glaſſes are two Mirrours; (1.) A plain tranſparent one, placed within the Bottom of the Caſe at LN, on which the Objects to be view'd are laid, in the Middle thereof, as at *o*. This Glaſs may be taken out and in at Pleaſure. (2.) The other is a quick-ſilver'd Mirrour contain'd in the lower Part of the Braſs Bottom R, its Uſe is to reflect Light on tranſparent Objects while we view them.

THE *Micrometer* conſiſts of two Parts, the Plate and Screw. (1.) The Plate is repreſented at X in its proper Size; and is graduated into ten large Parts, each of which is divided by a Dot into two; ſo that in the whole there are 20 Parts or Diviſions in the Circumference. (2.) The Screw *oq*, and ſmall Index *qr* are repreſented in *Fig*. 2, on this Screw there are 50 Threads to an Inch;

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ſo that one Turn or Revolution of the Index moves the Screw $\frac{1}{50}$ of an Inch backward or forward. But of this more hereafter.

THE braſs Top at A is common to all *Microſcopes* of the better Sort: But the braſs Bottom EFR is peculiar to this; it conſiſts of two Parts, *viz.* (1.) EF, which is ſtrongly faſten'd into the *Microſcope* on the upper Part; and on the lower Part is a Rim or Border on which (2.) the other Part or Box, containing the Mirrour, ſhuts very faſt, and on the hinder Part is connected to the other by a very ſtrong braſs Joint, by which Means it is at any Time eaſily let down for the Reflection of Light, or ſhut up again when in diſuſe.

IN the Caſe or Body of this *Microſcope* are two Apertures; a large one before, as LMN, to place the Object, and admit the Light; and a ſmall one behind, as PQ, in which we place a long Piece of plain Glaſs S, for moving the Object this way and that; or a ſmall hollow Tube thro' the round Hole, which Tube is repreſented by T.

THE Uſe of the Tube is to contain living Subjects for viewing the Circulation of the Blood, *&c.* as an Eſt, a Frog, a Fiſh, *&c.* As *Animalculæ* in *Water*, *&c.* are placed under the *Microſcope* in the ſmall Concave V. Which Tube and Concave Glaſs are ſold with the *Microſcope*.

CHAP. II.

Of the Manner of Magnifying Objects; and of procuring diſtinct Viſion by the Microſcope.

IN order to form a proper Notion of the Magnifying Power of the *Microſcope*, or the Method of computing it, without the Mathematical Theory, we muſt well attend to the following Obſervations or Rules.

Firſt, If Parallel Rays, as thoſe of the Sun, fall on any Convex Lens, they will be all collected into one Point on the other Side: Which Point is call'd the *Focus* of the Glaſs; and its Diſtance from the Glaſs, its *focal Diſtance.*

Secondly, If therefore an Object be placed in the Focus of ſuch a Lens, the Rays after having paſs'd thro' it, will proceed parallel, and form an Image at an infinite Diſtance.

Thirdly, If an Object be placed farther from the Lenſe, than the Focus, all the Rays coming from any one Point of the Object, having paſs'd thro' the Lens, will be united in a certain Point on the other Side; and the Diſtance of this *ſecondary Focus* (for ſo I here call it) is found by the following Rule; *viz. Multiply the focal Diſtance by the Diſtance of the Object; divide that Product by the Difference of thoſe two Diſtances, the Quotient is the Diſtance of the ſecondary Focus or Image.*

Fourthly, If the Object be placed nearer to the Lens than is its Focus, the Rays going from any Point thereof having paſs'd the Lens, will proceed leſs diverging, as if they came from a Point farther from the Lens than the Object; which Point is the ſecondary Focus, and is now negative, or on the ſame Side with the Object.

Fifthly, THE Object and Image are ſeen under equal Angles from the Vertex of the Lens; and are therefore to each other as their Diſtances directly.

Sixthly, THE Eye can only have diſtinct Viſion when the Rays fall on it parallel, or very nearly ſo; becauſe the *Retina*, which is the Organ of Sight is placed juſt in the Focus of the Cryſtalline Humour, which performs the Office of a Lens in collecting Rays, and forming the Image in the Bottom of the Eye.

THESE Theorems, and all others relating to theſe Matters, are fully demonſtrated in my *New and Compendious Syſtem of Optics*.

SINCE no diſtinct Viſion can be produced but by parallel Rays, and no parallel Rays can proceed from a Lens, but when the Object is placed in the Focus thereof; it evidently follows, that whatever we view in the *Microſcope* by means of the upper Eye-Glaſs, muſt neceſſarily be ſituated in the Focus of that Glaſs. Thus ſuppoſe the Glaſs be G H, and let its focal Diſtance L B be 1½ Inch; then will B the Focus, be the Place of every Thing that appears clearly and diſtinctly thro' the *Microſcope*.

I NEED not ſay, that whatever appears or is ſeen in that Focus, is not the Object we propoſe to view, but its Image there form'd by means of the other Glaſſes. How this is done by the Object Glaſs *d e* alone is eaſy to conceive. For ſuppoſe the focal Diſtance *f b* be half an Inch, then if an Object *a e* be placed at a ſmall Diſtance beyond, or below the Focus *b*, the Rays which proceed from every Point thereof falling on the Lens *d e*, will be converg'd at ſome conſiderable Diſtance in ſo many Points on the other Side, and there form an Image of the Object; and this Image will be as much larger than the Object, as its Diſtance from the Lens *d e* is greater than the Diſtance of the Object.

Now 'tis eaſy to underſtand that as this Lens *d e* is contain'd in the Button K, by ſliding the Tube H a little up and down, its

Diſtance from the Object O may be ſo adjuſted that the Diſtance of the Image ſhall throw it juſt in the Focus of the upper Eye-Glaſs at B, where it will be very clearly ſeen by an Eye at I.

But if beſides the Object Lens *de*, and the Eye-Glaſs GH, there be interpoſed another Lens DE; this Lens will intercept the Rays before they are converged to the Focus of the Eye Glaſs GH, and will cauſe 'em to converge or meet ſooner, and ſo form an Image below the Focus of the ſaid Lens GH, which therefore cannot be ſeen diſtinctly thro' it.

Hence, in this Caſe, 'tis neceſſary to move the Lens *de* a ſmall Matter nearer to the Object than before, in order that its Image might be thrown ſomewhat above B (if the Glaſs DE were away) as to MN, that by means of the Glaſs DE the Rays might be converg'd and the Image form'd lower, *viz.* in the Point B, the Focus of GH; where it will be again viſible as before.

So that in either Caſe, of one or two Eye-Glaſſes, 'tis eaſy by ſliding the Tube H up and down judiciouſly, to get the Image form'd preciſely in the Focus B, where only it can be perfectly and diſtinctly diſcern'd.

The principal Uſe of the lower Eye-Glaſs DE is to enlarge the View, or what is call'd the *Field of Viſion*, or that circular Area which is viſible in the *Microſcope*; for 'tis evident by interpoſing the Glaſs DE, the Angle D*f*E will be conſiderably increaſed; and conſequently ſo will the Angle *afc*: But the greater the Angle *afc* is, the greater Length of the Object *ac* will be taken into the View; for all the Object between the Rays *af* and *fc*, will be ſeen in the *Microſcope*. And the more of the Object can be ſeen, the pleaſanter will be the View.

But tho' by the Glaſs DE, a greater Part of the Object is brought into View, yet the viſible Part of the Image depends on the largeneſs of the Lens HG; for ſince the Image is in the Focus B, no Rays will be convened at the Pupil of the Eye at I, but what procoed parallel from it to the Lens, as CH, BL, AG, conſequently the viſible Part of the Image is equal to the Area of the Lens G H; and is therefore greater or leſſer as that is ſo.

CHAP. III.

The Method of computing the Magnifying Power of the Microſcope.

SINCE we find by common Experience that no Object can be diſtinctly ſeen by the naked Eye at leſs than *ſeven Inches Diſtance*; and, in the Generality of Eyes, perhaps, not at leſs than *eight:* And alſo ſince any Object is viſible diſtinctly thro' a Lens, when placed in the Focus thereof; it muſt follow, that the Object will appear as much bigger thro' the Lens, than to the naked Eye, as it is nearer; that is, as the focal Diſtance of the Lens is leſs than 8 Inches.

FOR Example: Suppoſe I view an Object thro' a Lens of 1 Inch focal Diſtance, then will its Diameter or Length be magnified 8 times, its Surface 64 times, and its Solidity 512 times. In like Manner, if the focal Diſtance of the Lens were half an Inch, then would its Diameter be magnified 16 times, its Surface 256 times, and its ſolid Content 4096 times. Once more; if the focal Diſtance be a quarter of an Inch, the Diameter will be magnified 32 times, the Surface 1024 times, and the ſolid Content 32768 than by the naked Eye at the Diſtance of 8 Inches.

HENCE it appears how very conſiderable a Microſcope is a ſingle Lens. And indeed thoſe famous ones of Mr. *Lewenhoeck*, and the coſtly one of *Wilſon*'s Make, were nothing but ſingle Lenſes, whoſe focal Diſtances were exceeding ſhort; as the $\frac{1}{10}$, $\frac{1}{20}$, $\frac{1}{30}$, $\frac{1}{40}$, $\frac{1}{50}$, *&c.*

Part of an Inch; theſe magnify extremely, 'tis true; but that is far from ballancing the Diſadvantages ariſing from ſo great a magnifying; the Difficulty of making ſuch Glaſſes, of viewing the Object, the ſmall Part of it ſeen, the Expence of the Inſtrument, &c. has made it neceſſary to have recourſe to Compound Microſcopes for the Conveniency and Pleaſure of uſing them.

In theſe, if but two Glaſſes are uſed, (*viz.* an Object-Glaſs *de*, and one Eye-Glaſs H G;) a Computation of the Power of Magnifying would be very eaſy, in this Manner B is the Focus of the Glaſs G H, where the Image A C muſt be form'd; therefore the Length of the Image is to the Length of the Object, as the Diſtance *f* B (ſuppoſe 6 Inches) to the Diſtance *f b* (ſuppoſe half an Inch,) that is, as 12 to 1. And ſo much is the Object magnified by the ſmall Lens *de*.

Again, ſuppoſe the focal Diſtance of the Lens G H be $1\frac{1}{2}$ Inch; then as 8 Inches is to $1\frac{1}{2}$ (or as 6 to 1) ſo is the Magnitude of the Image ſeen thro' the Glaſs G H to what it would be ſeen by the naked Eye at the Diſtance of 8 Inches. So that the Image is magnified in Diameter 6 times by the Glaſs G H.

Therefore the whole Diameter of the Object *ac* is magnified by both the Lenſes 12 times 6, or 72 times; or its Length is 72 times greater in ſuch a Microſcope than it would appear to the bare Eye at the Diſtance of 8 Inches.

But this Conſtruction with two Glaſſes is not ſo good as one with three; tho' the Computation of the Magnifying Power be in this Caſe ſomewhat more intricate, yet it may eaſily be apprehended in this Manner: Suppoſe the focal Length of the Lens $de = \frac{1}{2}$ Inch, of D E 3 Inches, and of G H $1\frac{1}{2}$ Inch, and the Diſtance of the two Eye-Glaſſes L F = $2\frac{1}{2}$ Inches; then will F B = 1 Inch; and ſuppoſe F *f* = 5 Inches, then will *f* B = 6 Inches.

These Things premiſed; it muſt be remember'd that I ſaid the Lens *de* muſt be placed ſo near the Object *ac* as to throw the Image above the Point B (ſuppoſing the Glaſs D E away) to ſome

Point P, that upon admitting the Glaſs DE, the ſaid Image may be brought to the focal Point B as required. In order to this, the Diſtance F P muſt be determined, which is done (by having given the Diſtance F B = 1 Inch, and the focal Diſtance of the Glaſs DE 3 Inches) in the following Analogy.

As the Difference between BF and the focal Diſtance of DE, is to the ſaid Diſtance BF;

So is the focal Diſtance of DE to the Diſtance F P.

That is in the preſent Caſe, as $2 : 1 :: 3 : 1{,}5 = FP$.

Therefore fP added to Ff gives $fP = 6\frac{1}{2}$ Inches.

Now that fP may be $6\frac{1}{2}$, the Diſtance of the Object muſt be $\frac{54}{100}$ of an Inch; which is juſt 12 times leſs than the Diſtance fP; and therefore the Length of the Image MN would be 12 times greater than that of the Object *a c*.

By the Interpoſition of the Glaſs, the Image is brought down from P to B; draw M F, and N F, and alſo *s t* parallel to MN, then ſhall *m n* be the Length of the Image form'd a ſecond Time. Now 'tis evident, as fP is to F B, ſo is MN to *m n*; that is, in Numbers, $1\frac{1}{2} : 1 :: 12 : 8 = mn$; the Length of the Image, therefore, by the two Glaſſes, is 8 times that of the Object.

This being the Caſe; the Glaſs GH magnifies 6 times: Therefore the Object *a c* is magnified by this Microſcope 6 times 8, or 48 times in *Length*, 2304 times in *Surface*, and 110592 times in *Solidity*; by an Object Lens of half an Inch focal Diſtance. And in the ſame Manner it may be computed for any other Object Lens, whoſe focal Length is known.

From what has been ſaid, it appears, that as the Glaſs DE amplifies the *Area* or *Field of View*, ſo it contracts or diminiſhes the Image of Objects, one third of the Diameter or Length, in the Caſe before us; and yet this without any Diſadvantage; for a Microſcope may as well magnify too much as too little; a *Flea* may be magnified to the Bulk of an *Elephant*, but to little or no purpoſe. For the more an Object is magnified the more obſcure it appears; there is therefore a juſt Degree of magnifying, more or leſs than which would be a Fault: So true is the Obſervation of *Horace*,

> *Eſt Modus in Rebus*; *ſunt certi denique Fines*,
> *Quos ultra citraque nequit conſiſtere Rectum.*

THERE are other Methods by which the magnifying Power may be computed; but this, here deliver'd, I take to be the eaſieſt of any mathematical one, and may be applied for any focal Length of the Object Lens. But if this be not underſtood, the Reader will find a moſt plain and practical Method of finding how much the *Microſcope* magnifies with any Object Lens whatſoever, by the *Micrometer* only, at the End of the next Chapter, which he cannot fail to underſtand or practiſe.

CHAP. IV.

Of the Micrometer, *and its Uſe in meaſuring very ſmall Objects.*

THE Parts of this Inſtrument have been already deſcribed, from whence its Uſe will be underſtood in a very few Words.

THE *Micrometer o q* is fix'd in the Focus of the Eye-Glaſs G H, and therefore its Point *o* will be clearly ſeen to move over the Parts of the Image, and to be, as it were, coincident with it. When any Object or Part thereof is to be meaſured, the Point is to be ſet very nicely to one Side thereof, while the Index *q r* points to the Beginning of the Diviſions on the upper Part of the Plate, or Number 10. Then holding the Microſcope faſt with one Hand, with the other turn the Index till the Point of the *Micrometer* appears to be moved juſt over the Part, which will eaſily be diſcover'd by the Eye. Then obſerve how many Revolutions and Parts have been made, and you will eaſily know the Dimenſions of the Object, thus:

SINCE there are 50 Threads to an Inch, every Revolution will meaſure the 50th Part of an Inch in the Image; and ſince there are 20 ſmall Diviſions on the Plate, each of theſe will give the Meaſure of 1000th Part of an Inch in the Image, theſe 50th Parts and 1000th Parts added together, will give the whole Meaſurement made by the *Micrometer* on the Image; and ſince the Proportion between the Image and Object is ſuppoſed to be known, the Meaſure of the Object will be known alſo. But this Matter will be beſt apprehended by Example.

SUPPOSE one of the *Annuli*, or Rings on the Body of the Inſect A C, were to be meaſured: Set the Point *o* to one Side thereof, as repreſented in the Figure; then ſuppoſe the Index makes juſt one Revolution while the Point *o* moves juſt over the *Annulus*; you will immediately know the Thickneſs of the *Annulus* in the Image is juſt one 50th Part of an Inch: And then ſuppoſe the Image 8 times as large as the Object, it muſt follow that the *Annulus* of the Object is but one 8th of that 50th Part; that is, but one 400dth Part of an Inch. This is a plain Caſe.

BUT ſuppoſe in meaſuring another Part, you make 3 Revolutions, and 15 Parts of another, then the 3 Revolutions will be $\frac{3}{50}$ of an Inch, and the 15 ſmall Diviſions will be $\frac{15}{1000}$ of an Inch; theſe two added together, make $\frac{75}{1000}$ of an Inch in the Image, and therefore but $\frac{1}{8}$ ſo much in the Object, *viz.* $\frac{75}{8000}$, which is almoſt $\frac{1}{100}$ Part of an Inch.

NOTE, That $\frac{3}{50}$ added to $\frac{15}{1000}$ make $\frac{75}{1000}$, is eaſy to conceive by conſidering that every $\frac{1}{50}$ is equal to $\frac{20}{1000}$; and conſequently that $\frac{3}{50}$ muſt be equal to $\frac{60}{1000}$, which added to $\frac{15}{1000}$, make $\frac{75}{1000}$, as before.

Or thus in ſhort; make the Number of ſmall Diviſions, paſs'd over during the whole Motion, *the Numerator of a Fraction*, and the Number expreſſing the Power of Magnifying with three Cyphers annex'd, the Denominator of that Fraction; then will that Fraction expreſs what Part of an Inch the Part meaſured is equal to in the Object. Thus in the laſt Example, there were 75 Diviſions in all paſs'd over, which therefore is the Numerator; and ſince the Object was magnified 8 times, the Number 8 with three Cyphers, is the Denominator; and ſo the Fraction is $\frac{75}{8000}$, as above.

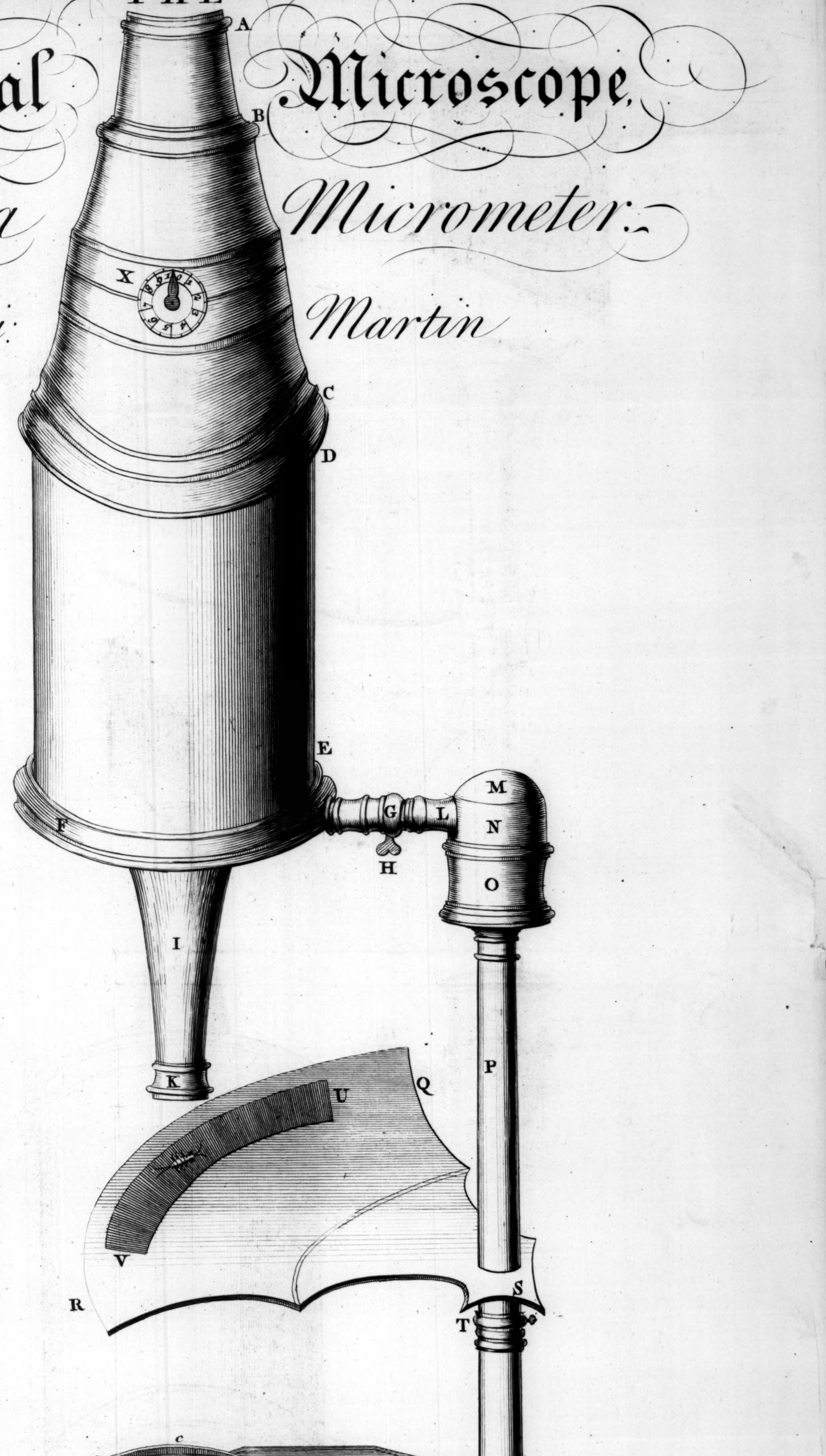
'Tis well known by Experience, that the 100dth Part of an Inch is viſible to the naked Eye: In a Microſcope, therefore, that magnifies 4, 6, 8, or 10 times, the 400dth, 600dth, 800dth, or 1000dth Part of an Inch will be viſible, and therefore may be eaſily meaſured by the Micrometer. And ſince the thouſandth Part of an Inch may be ſo eaſily ſeen and meaſured, we may judge very nearly of others much leſs, at leaſt 10 times leſs; thus we may be certain of the ſurprizing Minuteneſs of Objects almoſt to the 10000dth Part of an Inch in Diameter, the 100000000dth Part of a ſquare Inch in Surface; and the 1000000000000dth Part of a Cubic Inch, in Bulk, or Solidity. To what a prodigious Degree, then, does the Microſcope, thus conſtructed, extend our *Geometry*, as well as our Philoſophy!

In the laſt Chapter I promiſed an eaſy Method of finding the *Magnifying Power* of the Microſcope, for any Object Glaſs, by the Micrometer; which is done in this Manner: Take any Ruler, *&c.* which has Inches divided into *Tenths*, and place it under the Microſcope ſo that you may have one of thoſe Tenths in full View in the Image, then meaſure it carefully with the Micrometer, and count how many Turns were made in ſo doing; divide that Number by 5, and the Quotient will ſhew how many times the Image is bigger than the Object. Thus ſuppoſe in Meaſuring one of thoſe Tenths I make 40 Turns, that divided by 5 quotes 8; and ſo many times does the Microſcope magnify with the Glaſs.

Note,

THE Universal Microscope, with a Micrometer.

By Benj: Martin



These
Microſcopes
are Sold by
J. Newbery
Bookseller
in
Reading Berks.

Eman: Bowen Sculp.

Note, the Reaſon why you divide by 5, is becauſe there being 50 Threads to an Inch, 5 muſt be equal to one Tenth in the Object; and therefore as many times 5 as there are in the Image, ſo many times muſt the Object be magnified.

CHAP. V.

A Deſcription of the UNIVERSAL MICROSCOPE, *mounted on a* BALL *and* SOCKET.

THE uſual Conſtruction of the large double Microſcope confines its Uſe to thoſe Objects only which are placed *below it*, on a circular Plate of Braſs, included between, and ſupported by the three braſs Legs of the Microſcope. Hence only one Poſition of the Microſcope, and only thoſe Objects which can be put between the ſaid Legs, can be of uſe in this Structure.

To remedy this Inconvenience, by applying the ſaid large double Microſcope to view all Kinds of Objects in every poſſible Poſition or Situation, I have contrived a new Form or Structure thereof, by means of a *Ball and Socket*, mounted on a cylindric Shaft of Braſs, on which a Quadrantal Plate of Braſs moves horizontally, all which are repreſented in *Plate* II, as large as the Inſtrument itſelf. A particular Account of which here follows:

A, is the Braſs Top of the Microſcope.
A B, the Part containing the upper Eye-Glaſs.
B C, the Part containing the lower Eye-Glaſs, and Micrometer X.
D E, the Tubes, or Body of the Microſcope.

I, K, the Snout, and Button, with the Object-Glaſs.
F, F, a ſtrong hollow Ring or Socket of Braſs, in which the Body of the Microſcope is fixed.
F G, a Braſs Arm, in the Cavity of which, G, is faſten'd
L, the Neck of the Braſs Ball, by
H, a ſmall Screw.
M, the Braſs Ball.
N O, the Socket which contains it; the Part N ſcrewing on the other Part O.
P, the Braſs Stem or Shaft, on which the Socket O is ſcrew'd.
Q R S, a Quadrantal Piece of Braſs moving horizontally on
T, a ſmall Braſs Socket moveable on the Stem P, and fix'd at Pleaſure by a Screw.
V U, a Circular Piece of Glaſs, on which the Object is laid.
W Y, the Box or *Baſis* of the Microſcope, with a Drawer, Z, containing the other Buttons, Glaſſes, *&c.* which belong to the Microſcope.
a, *b*, *c*, *d*, the Braſs Caſe, containing the Mirrour for Reflecting Light thro' tranſparent Objects.

FROM this Deſcription and Repreſentation of the Parts, 'tis eaſy to obſerve how much this Form of the Microſcope excells that in common Uſe; for (1.) By means of the *Ball and Socket*, the Microſcope may be applied to view Objects in any Situation obliquely, as well as perpendicularly below it, which the other cannot. (2.) Objects of any Shape or Form, or placed in any convenient Veſſel, may be here placed under or before the Microſcope, which very often cannot be done in the uſual Form, by reaſon of the Nearneſs of the Legs to each other. (3.) Objects placed on the Quadrantal Plate R Q may be moved horizontally under the Inſtrument, 'till all its Parts ſucceſſively paſs under the Object Glaſs, or are ſeen in the *Field of View*; which Plate in the other is fix'd and immoveable. (4.) Tranſparent Bodies are view'd to a much greater Advantage by means of the long circular Piece of Glaſs V U, which paſſes thro' the whole Length of it under the Object Glaſs, than in the common Sort where the Hole is circular and immoveable; becauſe (5.) here the Object, once well poſited, is not moved, but the Plate whereon it lyes; but *there*, 'tis moſt times neceſſary to move the Object itſelf this way and that, which is very inconvenient. (6.) The Beauty, Simplicity, and Freedom ſo conſpicuous in the Structure of this Inſtrument muſt recommend it to every Gentleman of good Taſte, who chuſe to have a Microſcope of any other than the *Pocket Form.*

THEY who are converſant in the Microſcope will eaſily judge with how much Eaſe and Pleaſure the grand *Phænomena* of the *Animalculæ* in Water, in *Semine Maſculino*, the Circulation of the Blood, and various other Philoſophical Experiments, will ſucceed in this more than in any other Form yet invented for the larger Microſcope.

IN the firſt Edition of this Piece I gave a Print of this *Univerſal Microſcope* ſomewhat different from this, and which was very well approved and accepted; but as very few Things are perfect with the firſt Thought, ſo this Inſtrument, upon mature Deliberation, I found was capable of conſiderable Alteration and Improvement in its Structure, both in regard of Elegance and Uſefulneſs; and with which they are now made accordingly. I likewiſe gave the Print of the former in Miniature, but here the whole, and every Part, has the ſame Size and Proportion as the Microſcope itſelf; which I judged was neceſſary to exhibit a juſt and adequate Idea of the ſame.

CHAP. VI.

A Computation of the extreme Minuteneſs of viſible Animalculæ; *and the prodigious Subtilty of their Blood-Veſſels, and Sanguineous Particles.*

IN order to make a Calculation of the Magnitude of an *Animalcule* that is but juſt viſible to the Eye, we muſt know that 'tis found by Experience, *that an Object is then juſt viſible when it ſubtends an Angle of but one Minute to the Eye.*

NOW ſuppoſe the lower Glaſs DE taken away, and that the Diſtance of the Image BF is ten Times the Diſtance of the Object *bf* from the Lens *de*, then will every Particle in the Image be ten times greater than the ſame Particle in the Object.

AGAIN, ſuppoſe the focal Diſtance of the Eye Glaſs IL or LB be juſt one Inch; then a Particle in the Image, which is but juſt viſible to the Eye by ſuch a Glaſs, will be ſeen under an Angle of one Minute. Let ſuch a Particle be repreſented by AB (in *Fig.* III.) and the focal Diſtance of the Eye-Glaſs by $CB = 1$ Inch: Then in the Right-angled Triangle ABC there is given the Side $BC = 1$ Inch, and the Angle $C = 1$ Minute, to find the Length of the Particle AB.

IN this Caſe BC is *Radius*, and AB the *Tangent* of the Angle C; but when the ſaid Angle C is *one Minute*, the *Radius* is to the *Tangent* as 10.000.000 to 2909; that is, in round Numbers, as 10000 to 3; ſo that the Particle AB is in Length $\frac{3}{10000}$ of an Inch. All this is evident from the Tables of Sines and Tangents.

Now ſince A B is equal to $\frac{3}{10000}$ in the Image, and the Image is 10 times larger than the Object, the ſaid Particle in the Object will be but $\frac{1}{10}$ of $\frac{3}{10000}$, or $\frac{3}{100000}$ Parts of an Inch. Now 'tis well known that there are ſome Animalcules in Water, ſo ſmall that when they are magnified 10 times they appear but as Points in the Microſcope; and as they are of a ſpherical Figure, the Diameter of one of theſe Animalcules may be repreſented by AB $= \frac{3}{100000}$; and therefore the Magnitude of the Animalcule muſt be expreſs'd by the Cube of that Number, *viz.* $\frac{27}{100000.00000.00000}$ multiplied by 0.5236, which makes $\frac{14}{100.000000.0000000}$, that is, if a *Cubic Inch* were divided into a *Thouſand Millions of Millions of equal Parts*, the Magnitude of one of theſe Animalcules would be equal to but 14 of them.

Hence (ſays Dr. *Keill)* what ſome Philoſophers have dreamed concerning Angels, is true of theſe ſmall Creatures, *viz. That many Thouſands of them may dance on the Point of a ſmall Needle.*

From the above Calculation it appears, that the Concavity of a Globe $2\frac{1}{2}$ Inches Diameter, will contain more than a *Thouſand Million of Millions* of thoſe *Animalculæ.*

Since the Veſſels of organized Bodies are in Proportion to the Magnitude of the Bodies, as we may reaſonably ſuppoſe; and ſince the human Body contains, at a Mean, about 3 Cubic Feet, or 5184 Inches; therefore as 5184 is to $\frac{14}{100.000000.0000000}$, ſo are the ſmalleſt Veſſels diſcoverable in a human Body to the like Capillary Veſſels in an Animalcule.

But Capillary Veſſels have been obſerved in the human Body ſo ſmall that the Diameter of one of them is but about $\frac{1}{80000}$ Part of an Inch; now the Diameter of a like Capillary in the Animalcule will be in proportion to the above Diameter $\frac{1}{80000}$, as the Cube Root of the Magnitude of the Animalcule $\frac{14}{100.000000.0000000}$ to the Cube Root of the Magnitude of the human Body 5184. But the Cube Root of 5184 is nearly 17, and that of $\frac{14}{100.000000.0000000}$ is nearly $\frac{2{,}4}{100000}$; therefore as 17 is to $\frac{2{,}4}{100000}$ ſo is $\frac{1}{80000}$ to $\frac{2{,}4}{1360000.00000}$ or $\frac{1}{57.000.000.000}$; which therefore expreſſes the Diameter of the Capillary in the Animalcule; that

is

is in Words, if an Animalcule be divided into *Fifty-ſeven Thouſand Millions of equal Parts*, then will the ſaid Diameter be equal to *one of them*.

Now the Diameter of a Blood-Globule which flows thro' one of theſe Veſſels, muſt be leſs than $\frac{1}{57.000.000.000}$ Part of an Inch; therefore if we ſuppoſe thoſe Globules round, the Solidity or Magnitude of one muſt be leſs than the Cube of $\frac{1}{57.000.000.000}$ multiplied by 0.5236; that is leſs than $\frac{1}{96948.000000000.000000000.000000000}$, or in round Numbers $\frac{1}{100000.000.000.000.000.000.000.000.000.000}$ Parts, which Number being ſo exceeding ſmall, cannot be expreſs'd in Words that will give a clear Idea of ſuch an extreme Subtilty of the Particles of the Fluid which circulates thro' the Capillaries of thoſe *Animalculæ*.

I shall therefore take another Method to aſſiſt the Conception in this Matter, which is by finding a Mean Proportional between the Magnitude of the aforeſaid Particle, and that of the the Globe of the whole Earth. To this Purpoſe I ſhall conſider the Earth as a Sphere whoſe Diameter is 8000 Miles. Therefore the Solidity of the Earth is equal to 512000.000.000 multiplied by 0.5236, that is to 268083200.00 Cubic Miles; and in one Cubic Mile there is 254358061056000 Cubic Inches: Therefore the Magnitude of the whole Earth is 681.890.000.000.000.000.000.000.00 Cubic Inches (true enough for the Proportion.) A mean Proportional therefore between the Numbers expreſſing the Magnitude of the Earth and the Particle, muſt be the Square Root of this Fraction $\frac{681.890.000.000.000.000.000.000.00}{1000.00.000.000.000.000.000.000.000,000.000}$, *viz.* the Fraction $\frac{8257645000.000}{10.000.000.000.000.000}$; this being divided by 0.5236, and the Cube Root of the Quotient extracted, will be the Diameter of a mean Proportional ſought, *viz.* $\frac{20212}{175640}$, or $\frac{20}{173}$; which is little more than one Tenth of an Inch. *Therefore a Globe or Ball of one Tenth of an Inch Diameter, is a mean Proportional between the Globe of the Earth and one of thoſe ſanguineous Particles: Or ſuch a Particle is as much leſs than a Globe of one Tenth of an Inch Diameter, as that Globe is leſs than the Globe of the whole Earth.*

IN this *Calculus* we have ſuppoſed nothing abſurd, yea nothing that is not agreeable to the Analogy which Nature obſerves in all her Operations. If Magnitudes increaſe or decreaſe in ſuch extreme and remote Gradations as ſurpaſs our Comprehenſion or Conception, it makes nothing againſt the Poſſibility or Probability of the Thing; the Proportion is all the Difference, which is indifferent to Nature, and only affects us. We think the infinite Diviſibility of Matter a ſtrange and incredible Thing, yet nothing admits of a more ſtrict Mathematical Demonſtration. The Globules we have been conſidering, and think ſo wondrous ſmall, we ſhould think, perhaps, as monſtrouſly large, could we compare 'em with other Bodies in the *Scale of Miniature* below them; as the Particles of the Fluid in which they float; or thoſe of the animal Spirits in thoſe *Animalculæ*; or laſtly, to the Particles of Light, which probably are as much leſs than thoſe Blood-Globules we have been computing, as we have found them leſs than the Globe of the Earth.

HENCE then we conclude, there is *either nothing*, or *every thing*, to be wonder'd at in Nature: And that of the infinite Scale of Magnitude we view but a very few Steps or Degrees, even when aſſiſted by the beſt of Microſcopes and Teleſcopes (the only Helps in this Caſe which Art can afford us:) How very narrow, then, and contracted muſt be the Extent of their Speculation and Ideas, who are Strangers to theſe excellent Inſtruments, and are confined ſolely to the Notions derived from their *natural Sight and Senſes?*

CHAP. VII.

General Directions for the right Uſe of the Microſcope.

THE Glaſſes ought to be look'd at when you view an Object, to ſee that they are perfectly clean and clear; if they are not, they muſt be taken out and wiped with a Piece of ſoft Leather, fine Linen, or Silk, doubled over the Glaſſes; and replaced without touching 'em with the Fingers unleſs by the Edges only.

IN replacing the Glaſſes, Care muſt be taken to lay them level or even in their Places; for if they ſhould be placed obliquely, the Object will be diſtorted and diſcolour'd.

IN viewing an Object, always be ſure to hold the Microſcope perpendicular or down-right, and not aſlaunt; for then the Object, if unconfined, will roll out of Sight.

TAKE Care to hold the large Aperture towards the Light, that the Object may be as much illuminated as poſſible, and to the beſt Advantage.

IN ſetting the Microſcope for View, hold the outer Caſe firmly and ſteadily with the Left-hand, and with the Right-hand very gently move the inner Tube up and down till you find the Object, and have got a clear and diſtinct Sight of it; and there let it ſtand.

FOR the better apprehending the Object, be careful to lay it juſt on the Middle of the Glaſs, under the Object Lens in the Button. For thoſe Rays which come from the Middle, afford the moſt perfect Viſion; the Collateral Rays being very unfit for that Purpoſe.

HOLDING your Eye over the Aperture of the Braſs Top, move it gently up and down till you find the Place where you have the cleareſt and largeſt View of the Object, for ſuch a particular Point there is.

If there be ſeveral in company, each Perſon ought to ſet the Microſcope to his own Eye; and not view it as ſet by another; for every particular Eye has a Focus peculiar to itſelf.

If the Object does not appear exceeding clear and perfect, you may conclude the Inſtrument is not well adjuſted.

Let the Part to be viewed be ſo placed as to receive the ſtrongeſt Light, if the Object be a dark, black, or opake Subſtance.

If the Object be tranſparent, let down the Reflecter in the braſs Bottom, that the Light may be reflected ſtrongly thro' it. Nor is this Mirrour of any Uſe but when the Object is pellucid; and ſhould therefore in all other Caſes be ſhut up.

For larger Objects the larger Object-Lens is to be uſed, and for ſmaller, the ſmaller Lenſes; alſo the Object ſhould be as much magnified as it will bear that you intend to meaſure with the Micrometer.

Extremely ſmall Objects ſhould have the ſtrongeſt Light of the Sun, and the greateſt Magnifier. If it be the Circulation of the Blood, the Seminal Animalcules, or thoſe ſmall ones which tinge the Water; they ſhould be moreover illuminated by the Sun's Rays collected by a Convex Lens held in the Hand.

In a dark Day, or darkſome Room, no one ſhould attempt to view Objects, unleſs white, or of ſome ſtrong bright Colour; for if the Object be not well enlighten'd it will appear but dimly, and give no Satisfaction; whence a very ill Opinion is conceived of the Inſtrument without any other Reaſon but their own Unſkillfulneſs in the Uſe.

In looking into the Microſcope, take Care not to let your Breath fall on the Eye-Glaſs; and that you hold not your warm Hand long on thoſe Parts of the Microſcope where the Glaſſes lye, for they contract a Moiſture from the Hand, which in the Appearance of a fine Dew, abſolutely obſtructs all Sight of the Object.

THESE Directions and Cautions are all I can think neceſſary for an Inſtrument whoſe plain and ſimple Structure ſo naturally indicate its eaſy and obvious Manner of Uſe.

CHAP. VIII.

Of Microſcopic Objects; *and firſt of* Animal Subſtances, *in the* Human Body, *and thoſe of* Quadrupedes.

HUMAN HAIR; its bulbous Root; its long ſmall Cylindric Form; the Subſtance, if black, opake; otherwiſe, tranſparent.

HORSE-HAIR; the ſame things, but more apparently.

HOGS BRISTLES; beſides what is common to Hair in general, theſe appear tubular or hollow; for the thin tranſverſe Sections will appear perforated in the middle, if nicely cut with a ſharp Pen-knife or Razor.

MOUSE'S HAIR; I mention theſe becauſe Dr. *Derham* relates ſome Things very curious and peculiar to them, in regard of their Structure; which, tho' I have often ſought for, I could never yet obſerve.

THE SMELLERS of Cats, Tygers, Leopards, &c. they are round, opake, and ſolid throughout.

THE CUTICLE, or SCARF-SKIN of the human Body; this appears to be made up of ſeveral Lays or Rows of exceeding ſmall Scales, lying partly on each other. Under theſe Scales are ſaid to open the Orifices of the excretory Ducts of the Glands ſerving to Perſpiration: Theſe are innumerable, and incredibly ſmall.

THE SKIN; in which are the *Papillæ Pyramidales*; infinite in Number; between theſe open the Orifices of the Ducts of the *Miliary Glands*; which Glands lye under the nervous Texture of the Skin.

MEMBRANA ADIPOSA; in this Membrane, which lyes next under the Skin, you ſee the Fat of Animals, and will find it to be an oily Subſtance, contain'd in an infinite Number of ſmall Veſicles, or little Bladders, which appear very plainly in the Fat of Beef, Mutton, *&c.* cut into very thin pellucid Slices when cold.

MUSCULAR FIBRES; theſe when ſeparated artfully in the muſcular Fleſh of Beef, Mutton, Bacon, *&c.* appear to be nothing but *Faſciculi*, or Bundles of fine capillary Threads or Fibrils, perfectly tranſparent, and nearly round; having in all Reſpects the Appearance of very fine pellucid Hairs. They are of different Sizes in different Animals; but larger in Fiſh than Quadrupedes, and largeſt of all in the Fleſh of Shell-Fiſh, as *Crabs*, *&c.*

THE NERVES; theſe appear to be a Bundle of long ſmall Pipes or hollow Fibres, as ſome Authors ſay, but I could never diſcover their Hollowneſs, or ſeparate 'em like the Fibres of Muſcles.

ARTERIES and VEINS; the Coats which compoſe them, when ſeparated in a proper Manner afford a fine Subject for the Microſcope.

THE INTESTINES or GUTS; their Texture conſiſting in the various and wonderful Diſpoſitions, Order, and Direction of the nervous Fibres, make a curious Speculation.

THE LACTEALS; thoſe fine Ducts imbibe the Chyle from the Inteſtines, and are only to be ſeen in living Subjects.

THE LYMPHADUCTS, are of a curious Structure and Form, and well worth a Microſcopic Obſervation.

THE LUNGS, LIVER, KIDNEYS, PANCREAS, SPLEEN, *&c.* when diveſted of their parenchymous Subſtance by Maceration, diſcover a ſurprizing Contexture of veſicular, and vaſcular Ramifications of Arteries, Veins, Nerves, *&c.* inoſculating with each other, and make a wonderful Subject.

THE SEMINAL VESSELS; their wondrous Contortions and Convolutions in the *Epididymis*.

THE TESTICLES; the fine and beautiful Ramifications of Blood Veſſels on the Membranes incloſed; their glandulous Subſtance artfully dryed, and cut into thin Slices, are a delicate Subject. Thoſe of Bulls or Horſes are beſt for this Purpoſe.

THE PENIS; its cavernous or cellular Subſtance, when prepared and dryed; alſo the Subſtance of the *Glans* makes a curious Sight.

THE BRAIN; wherein the cineritious and medullary Subſtance, the Union of the Nerves, the *Plexus Choroides*, the *Rete Mirabile*, *&c.* are Subjects for the Microſcope: As alſo the *Meninges*, or *Pia* and *Dura Mater*, the Membranes which contain the Brain and *Cerebellum*.

THE EYE; here the ſeveral Coats, the Aqueous, Vitreous, and eſpecially the Cryſtalline Humour, deſerve a particular Inſpection; the Colour of the *Iris*; the Fibres of the *Ligamentum Ciliare*, and *Choroides*; and above all the *Retina* or fine Expanſion of the Optic Nerve, with the Branchery of Blood Veſſels thereon, afford the fineſt Entertainment to the Microſcopic Obſerver.

THE NOSE; in this Organ we have the *Oſſa Spongioſa*, and the Expanſion of the Olfactory Nerve over all its *Laminæ*; the glandulous Membrane, and the *Vibriſſi* or Hairs, are worth our Notice.

THE EAR; the Hair, the Wax, the *Tympanum* or Drum, the little Bones, the Auditory Nerve ſpread over the ſeveral Cavities, may be examin'd by the Microſcope.

THE TONGUE; the curious Diſpoſition of the Fibres (which compoſe its Subſtance) in ſeveral Planes, and various Directions, afford a pleaſing View; and more eſpecially ſo, the nervous *Papillæ* (which are the immediate Organs of *Taſte)* in the internal Membrane or Coat of the Tongue, and their Caſes in the external

Membrane, which make the Tongue ſo rough, and are ſo viſible and large in a Neat's Tongue, and other large Animals.

The Blood; this vital Fluid yields the ſublimeſt Speculations by the Microſcope in regard of the following Particulars, *viz.* the ſmall red Globules or Particles, which conſtitute the red Part, or *Craſſamentum*; and theſe are eaſily viſible if diluted with Water, and laid thin on a Glaſs: Some ſay each of theſe Globules conſiſts of *Six leſſer Ones*, but that I could never yet be apprized of. Theſe red Particles by a conſtant Dilution with Water will loſe their Colour, and become white Blood. By this Dilution of the Blood its Salts are extracted, and when the Humidity is evaporated, they appear very plain on a Glaſs laid under the Microſcope. The *Serum* of the Blood conſiſts of an infinite Number of fine inviſible Filaments, Membranes, and vaſcular Parts, ſome of which are obvious to the Eye by the Microſcope, and this is the Reaſon why the leaſt Heat will cauſe it to coagulate. But the moſt noble Phænomenon is the *Motion or Circulation of the Blood.* The principal Subjects for this Purpoſe are the tranſparent Tails of Tadpoles, and the yellow Sort of Water-Eſt or Neut; it is viſible alſo in the Fins and Tails of moſt Sorts of Fiſh and Eels, and likewiſe in the Feet of Frogs, &c. To ſee this with the greateſt Pleaſure, uſe the largeſt Magnifier, and let the Object be confined in the long Glaſs Tube, and the Part for View well enlighten'd by a Refracter above, and the Reflecting Concave below. If the Animal be near expiring, you'll plainly ſee the Motion of the Blood decreaſe, and the Globules glide ſlower and ſlower along, till at length they are perfectly quieſcent, and the Animal quite dead.

The Semen; the infinitely ſmall and numerous *Animalculæ* in all Male Sperm are the moſt aſtoniſhing Spectacle, and as yet the higheſt Attainment of the Microſcope; you cannot fail of ſeeing Millions of theſe in the ſmalleſt Quantity of the human Semen, if laid under the Microſcope while warm, and view'd with the greateſt Magnifier, and moſt ſtrongly illuminated, by the Sun's Light refracted and reflected upon it.

THE URINE; in this the various Sediments; the *Arenæ*, or Sand; the *Nebulæ*, or Motes; and the Salts obtain'd by evaporating the humid Part, are proper Subjects for the Microſcope.

THE BONES; theſe in the Fœtal State are ſoft and ſpongy, conſiſting of an Aſſemblage of bony Fibres, which are very wonderful to behold; theſe curious Objects are to be ſeen among the Preparations of Anatomiſts and Surgeons.

THE NAILS and HOOFS of Beaſts; the latter in Cows, and eſpecially in Horſes, are very porous, as may be eaſily ſeen by cutting their Slices, and laying them under the Glaſs with the Light reflected thro' them. Whence it appears, that the Nails and Hoofs of Animals are made up of innumerable ſmall cylindric *Tubulæ*, or Pipes, which are, as it were, cemented or conglutinated together, by a viſcous, hard, or horny Subſtance. Some Things of this Kind are alſo to be obſerved in the Horns of Animals.

CHAP. IX.

Of Microſcopic Objects *peculiar to* Birds.

AMONG this Tribe of Animals, the firſt Thing which preſents itſelf for a Microſcopic View, is

THE FEATHERS; in theſe the wonderful Variety of beauteous Colours delights the Eye, aſſiſted to view them with a Glaſs. The Feathers of the Jay, the Pheaſant, the Peacock, the Mallard, *&c.* are ſurprizingly fine thus view'd. As to the ſeveral Parts of a Feather, the Plumage is that which deſerves our firſt Notice; theſe appear extremely pleaſant, if view'd either together, or ſeparately; each *Plumula* having then the Appearance of a large

Feather. Thoſe in the delicate white ſoft Feathers of the Oſtrich, or of a Peacock's Tail, afford theſe *Plumulæ* of the fineſt Sort. The *Quill-Part* and *Rib* of the Feather have nothing which ſtrikes the Eye; but the white Pith, if cut tranſverſely into extremely thin Slices, and laid on a Piece of Glaſs, will ſhew an admirable Contexture of Net-work; which ſhews that the Subſtance thereof is compoſed of an infinite Number of *Veſiculæ*, or ſmall Bladders.

THE HAIRY FEATHERS of the *Caſaware* are worth obſerving.

THE FINE LONG HAIRS which appear on the Bodies of moſt Fowl when pick'd, with their bruſhy Tops and bulbous Roots, may be view'd with the Microſcope.

The RED COMBS and GILLS of Cocks,

THE SCALY SKIN of the Legs,

THE WEB or *Membrane* in the Feet of Water Fowl, are all proper Subjects.

THE FLESHY FIBRES in general, and particularly thoſe of the *Gizzard*, ſhew a wondrous Mechaniſm; and are view'd with great Satisfaction, if the Gizzard be partly dried, and cut into thin Pieces.

IN large Birds the Subſtance of the BILL, or *Beaker*; and in ſmall ones, the *Lamellæ*, or thin Plates of the Skull, the Interſtice, ~~with the bony *Fibrillæ* which connect theſe Plates, are very~~ curious Subjects.

THE EGG is the moſt copious Source of Microſcopic Themes belonging to this Tribe; for in many there is a beautiful Variety of Colours, Tincts, and Dyes, which make a fine Appearance. The hard cruſtaceous Part or Shell, if ſeeth'd in Vinegar 'till it becomes ſoft, will appear to conſiſt of ſmall, white, hard Globules, or ſtony Particles, as it were cemented together on a ſtrong white Membrane; and with the Point of a Needle, or Penknife, may be eaſily ſeparated from each other. The Membrane which contains the *Yolk*, appears to be an opake Subſtance when dry. The *White* of an Egg ſeems to be a vaſcular Subſtance (ſomewhat like the vitreous Humour of the Eye,) on which Account it immediately coagulates by Heat; but affords nothing extraordinary to the View. The *Yolk*, or yellow Part, being boil'd hard, and when almoſt dry, gently rubb'd on the Glaſs, will ſhew that it conſiſts of very ſmall roundiſh Globules of a faint red Colour; which, 'tis ſuppoſed, are ſmall Bladders containing an oleaginous Subſtance proper for the Nutriment of the young Chick, while confined in the Egg.

THE COLOUR'D IRIS in the Eyes of ſome Birds, makes a very fine Object in the Microſcope.

THE BREAST BONE, SCAPULÆ, *&c.* in ſmall Birds, are almoſt tranſparent, and afford a curious View of the Courſe which the Veſſels take thro' their Subſtance. The *Meditullium*, or internal ſpongy Subſtance of Bones is better obſerv'd in thoſe of Birds than any other Animals.

THE BAT, or *Flutter-Mouſe*, is rather a *flying Quadrupede*, than any thing of the Bird-kind; and is a wondrous Connection of thoſe two Species of Animals. The peculiar Sort of membranaceous Wings are a fit Object for the Microſcope, and, I think, is all that intitles them to a Conſideration here.

CHAP. X.

Of Microſcopic Objects *peculiar to* Fiſhes.

NO Perſon unacquainted with the Microſcope can imagine what a glorious and beautiful Creature a *Fiſh* is. Were it poſſible to view the whole Body of a *Carp*, for Inſtance, as magnified by the Microſcope, I dare ſay a Perſon would pronounce it the fineſt Animal he had ever beheld with his Eyes. For

THE SCALES of that Fiſh, when view'd in the Microſcope, appear all beſpangled with Stars of a golden Hue, with a great Number of Specks and Spots delightfully interſperſed. In this Scale appears a beautiful Form and Texture, the Root largely denticulated, by which 'tis inſerted into the Body; from whence it appears ribb'd to the middle Part, where they radiate or ſpread like the Sticks in a Fan towards the curv'd Extremity, which is variouſly figured in the Scales of different Fiſhes. The Scales of thoſe we call Flat-Fiſh, are exceeding ſmall and beautiful, as in the Plaice, Flounder, Turbet, *&c.* The Scales of an Eel are a great Curioſity; they were never known but by the Microſcope; they appear perfectly tranſparent, of an oblong Form, and of a Reticular or Net-like Texture. In order to ſee theſe to the beſt Advantage, take a Piece of the Skin of the Eel on the Side, and while moiſt ſpread it on a Piece of Glaſs to dry very ſmooth; when thus dry'd the Surface will appear all over dimpled or pitted by the Scales, which lye under a Sort of Cuticle or thin Skin; this Skin muſt be raiſed with the ſharp Point of a Pen-knife, together with the Scale, which will then eaſily ſlip out, and thus you may get as many of them as you pleaſe. Or they may be tolerably well ſeen thro' the dried Skin, if it be thin and clear and ſtrongly illuminated by the Reflecter.

THE Skin of all Fiſh and Eels appears more or leſs variegated with a great Number of Specks, Spots, Tincts, and Colours of various Dyes; as any one will ſoon be convinced, by viewing the Skin of an *Herring*, but more eſpecially of a *Mackerel*, by the Microſcope.

INSTEAD of *Scales* ſome Fiſh are arm'd with ſmall but very ſharp-pointed Spines or Prickles which grow very thick all over the Surface of their Bodies; theſe are moſt remarkable in that which we vulgarly call a *Seal's Skin* (which on this Account is of great Uſe among Joyners;) they appear, when view'd by the Microſcope, to conſiſt of ſeveral ſingle *Spiculæ* proceeding from a large

Baſe, and terminating in a ſharp Point at Top, which is ſomewhat curv'd, that ſo they might lay the faſter hold on any thing they are ſtruck into.

SOME Fiſh have neither Scales, nor *Spiculæ*, but have their Armour purely defenſative; as is evident in that curious Inſtance of what Tradeſmen call the *Nurſa-Skin*; this Skin is beautifully ſtudded all over with hemiſpherular Bodies, ſome large, ſome ſmall, with white Heads; ſpeckled on the outſide, within white as Ivory, and harder than a Bone. So that this Fiſh-Skin makes a Coat of Mail impenetrable even to Steel. It is of great Uſe in covering the Caſes of Microſcopes, Teleſcopes, and thoſe for Chirurgical Inſtruments.

THE SKIN which covers the *Saw* of the *Saw-Fiſh*, is a moſt curious Subject for the Microſcope; but whether the Skin which covers the Body of that Fiſh be in the ſame Manner decorated, I cannot ſay, having never ſeen more of that Fiſh than the Saw.

THE FINS of *Fiſhes* are a wondrous fine Subject; for they are beautifully colour'd, and ſtellated beyond any other Part; they conſiſt of hard, round, ſpinous, jointed Ribs, connected together by a tranſparent Membrane; on which Account the Blood-Veſſels are very viſible in the Fins and Tails of Fiſhes, and conſequently the Circulation of the Blood thro' them; which here may be ſeen as evidently as in almoſt any Subject whatſoever.

THE FLESHY FIBRES of *Fiſh* appear to be larger than thoſe of any other Animals, as I have already obſerv'd, particularly thoſe of Crabs, Lobſters, *&c.* But what is moſt remarkable is the Diſpoſition and Direction of thoſe Fibres (in the Fleſh of ſome large Fiſhes) which lye next the Skin; for in the Fleſh which is left on the *Nurſa-Skin* we find an infinite Number of *Strata* or Layers of Fibres lying on each other, the Fibres of one *Stratum* being preciſely at Right Angles with thoſe of the other. Hence if two of theſe *Laminæ* or Layers of Fibres be carefully ſeparated from the reſt (as may be eaſily done by Maceration in cold Water) they will then ſo nicely repreſent a Piece of fine Linen, that I have more than once ſhewn it for ſuch, without any Diſcovery of the Deceit; for tho' in Linen the Threads are interwoven, and in the Fleſh of Fiſh they lye upon each other, yet the Appearance is much the ſame in both; ſo nearly does Nature and Art, in this Caſe, coincide.

THE SPERM, or *hard Roe of Fiſhes*, appears by the Microſcope to be nothing but an *Ovarium* of Eggs, which are larger or ſmaller in different Subjects, are perfectly round, and are in the Crab or Lobſter a very pretty Object, when magnified.

THE TEETH in ſeveral Fiſhes, and particularly in Eels, are ſo ſmall, ſo ſharp pointed, ſo regularly diſpoſed, as to make a delightful View in the Microſcope.

THE BRAIN, with the fine Ramification of Blood Veſſels, the ſeveral Nerves, *&c.*

THE EYE, its beautiful colour'd *Iris*, and perfectly round cryſtalline Humour, with the Expanſion of the Optic Nerve,

THE peculiar Structure of the Lungs, and other *Viſcera*,

THE GILLS, and their particular Make; are all Subjects which give particular Satisfaction and Pleaſure, when duly examined by the Microſcope.

THE EYES *of a Crab or Lobſter*, (and all of that kind) are of a particular Structure; the Body of the Eye is here of a long or oblong Form, not round as in other Animals; the Fore-part, or *Cornea*, is prominent and full of Lattice-Work, or ſmall Squares, each whereof is, we may ſuppoſe, an Aperture (if not an Object-Lens) to a ſmall long round Tube, which lyes immediately below it, and goes to the Bottom of the Eye; theſe *Tubulæ*, or fine Pipes:, may therefore be eſteem'd ſo many very ſmall Teleſcopes, or ſomewhat analógous thereto; and ſo one of thoſe Eyes may be look'd on as a compound Organ, conſiſting of ſo many ſimple Inſtruments of Viſion, as there are ſmall Tubes in its Compoſition. For as Nature does ſometimes produce an Infinity of Effects by one and the ſame Cauſe; ſo, on the contrary, ſhe very often furniſhes a very large Apparatus of Means or ſimple Cauſes, which all jointly conſpire to produce one ſingle Effect.

THE SHELLS of moſt ſorts of Shell-Fiſh have ſomething extraordinary in their Colours, Forms, or Contexture, diſcoverable by the Microſcope, which will be more than evident in viewing proper Parts of the Shells of Crabs, Lobſters, Oyſters, *&c.* The ſingle thin Plates or *Laminæ*, which compoſe the latter, appear of a Retiform or Net-like Texture; *i. e.* full of Pores, or ſmall Holes, but round.

THE FIMBRIÆ, or fringed Extremities of the Parts of the Shells of Crabs or Lobſters, and particularly the latter, are a beautiful Subject; for they appear to conſiſt either of hard briſtly Hairs alone, or elſe of theſe and other Parts, like *Feathers*, alternately ſet together. Theſe ſmall *Plumulæ*, or Feathers, are form'd moſt plentifully on the under Parts of the *Annuli*, or Rings of a Lobſter's Tail.

ANY one who will give himſelf the Trouble of diſſecting a Shell-Fiſh of the Oyſter, Muſcle, or Scollop Kind, will find himſelf well rewarded with an unexpected Variety of curious Microſcopic Objects, which will at once delight and inſtruct his Mind in the Knowledge of that Part of animal Nature, hitherto ſo very little known. I ſhould not have mention'd the Ordure or Excrement of thoſe Fiſhes (beſt view'd in a Scollop) but that it makes a moſt delicate Appearance, both in regard of the Matter, which ſeems to be an exceeding fine Earth, and the exquiſite fine and beautiful Impreſſion of the Inteſtine, which excludes it; a juſt Idea of which can only be had from the Microſcope, and not from any Deſcription in Words.

CHAP.

CHAP. XI.

Of Microſcopic Objects *ariſing from the various Kinds of* Inſects.

THE moſt evident and perfect Tranſition from one Species of Animals to another, is that from the Quadrupede to the Inſect in the *Gryllotalpa* or *Mole-Cricket*; a Creature of ſingular Beauty, and a ſurprizing Conformation of Parts; as indeed are all of the Inſect Tribe.

THIS Genus of Animals is very extenſive, and contains ſeveral ſubordinate Species; the principal of which are thoſe which follow; *viz.* (1.) The *Papilionaceous*, or the Butter-fly and Moth-kind; (2.) the *Apian*, or Bee-kind; (3.) the *Ichneumon*, or Fly-kind; (4.) the Gnat-kind; (5.) the Cricket-kind; (6.) the *Scarabæous*, or Beetle-kind; (7.) the Louſe-kind; (8.) the Spider-kind; (9.) *Aquatic* Inſects, of which the Species are almoſt innumerable.

IN the *Butterfly* every thing is wonderful, and the Subject of the Microſcope; as the curious *Head*, with the two *prominent hemiſpherical Eyes*, which are finely chequer'd, and of various Colours; and in ſome I have obſerved a ſort of Hair grow all over their Surface; which is a Particularity not to be found in any other Creature. The *Antennæ*, or Feelers, are the Objects which next preſent themſelves; and theſe in Butterflies conſiſt of a long round Shaft or Stem, with an oblong hollow Head at the Top, which contains a clear Lymph. In the *Phalæna* or Moth-kind theſe *Antennæ* are of a moſt curious Form, being in ſome of the large ones of a plumiform Shape, or like a fine large Feather, as are alſo thoſe which are bred of the Silk-worm. The *Proboſcis*, or long pointed Spears which theſe Inſects thruſt to the Bottom of Flowers, to gather from thence their Nouriſhment, is of an admirable Form, and curiouſly coil'd up when not in uſe. This Part is beſt view'd in the largeſt Sort of Moth. The ſeveral Parts in and about the Mouths of theſe Inſects are an odd and wonderful Appearance. But in this Species the moſt delightful Spectacle is that gay and rich Variety of Colour in their Wings, and that farinaceous or mealy Matter with which their Wings and Bodies are cover'd; the divers, diſtinct, and regular Forms and Appearance of which Phænomena never fail to give the greateſt Delight and Satisfaction, even to the moſt indifferent Beholder.

Of the *Apian*, or Bee-kind, the moſt conſiderable are the Hornet, the Bee, the Waſp, and the *Bombylius*, or Humble-Bee. In theſe we view a very fine Head, with two oblong prominent chequer'd Eyes; a curious Apparatus of Parts about the Mouth; with a large *Proboſcis*, with which the Bee collects the Mellific Particles of Flowers, *&c.* the Hair which grows on the Bodies, eſpecially of the Humble-Bee; the curious Legs, and fine Claws or Hooks on the Feet; the tranſparent membranaceous Wings, with the curious Divarications of ſtrong fibrous Ribs; and above all, and what is peculiar to this Species, the fine Spear in the Tail, which we call the *Sting*, with its barbed Top, and the Duplicatures of the *Vagina*, or Sheath which contains it; the *Annuli*, or Rings, which make the abdominal or hinder Part of the Body, which appear beautifully ſpeck'd and dimpled all over the Superficies.

I can't here paſs by the moſt curious and delightful Appearance of the muſcular Fibres, as they lye in ſmall Bundles of Fleſh in the middle Part of theſe Inſects, and are ſeen immediately upon diſſecting and raiſing that Part; this may be moſt ſucceſsfully attempted in the Humble-bee, after it has been dead two or three Weeks; for then the Fleſh is pretty dry and hard, and the *Faſciculi* or Bundles of Fibres may be taken out together, and are eaſily ſeparated or diſſever'd ſo as to obſerve them ſingly with the ſame Diſtinctneſs as the fleſhy Fibres of Quadrupedes, or larger Animals. The *Membranes* and *Viſcera* of Inſects, are alſo a moſt delicate Subject, eſpecially as they appear upon diſſecting the Abdomen of the largeſt Sort of Moth, the Hornet, the Buck-Fly, or *Grillotalpa.*

AMONG the *Fly-kind*, that which we call the *Dragon-Fly*, is the largeſt, and deſerves our firſt Notice; its very large tranſparent chequer'd Eyes, with their fine Colours; the beautiful Parts of the Head and Mouth; the exquiſite Colours, *&c.* of the Body; the Legs; and the large tranſparent membranous Wings of a peculiar Make and Texture, are all Objects for a Microſcopic View. In the *Fleſh-Fly* we find, perhaps, the moſt beautiful Head and Eyes that any Creature wears; nor are the Colours of its briſtly Body leſs noble, ſtrong, and glaring; particularly the green, the blue, and red of ſome that fly wild among the Trees of the Garden and Fields. The Eggs of the *Fleſh-Fly*, which we call *Fly-Bloats*, are a very pretty Spectacle in the Microſcope. Among the infinite Species of the *Fly-kind*, we find ſomething ever new and ſurprizing either in the Colour, Make, Size, or various Structure of the Parts, which would be endleſs to recount.

IN the *Gnat-kind* we find ſeveral remarkable Particulars; as their fine ſmall Head; round globous chequer'd Eyes; their curious ſmall, long, knotted, and hairy *Antennæ*, in ſome; in others they are bruſhy or plumiform; their very long and ſmall Legs, and hooked Claws; the Length and Tenuity of their Bodies; and laſtly, the long ſmall pointed Spear that goes from the Tail of ſome of thoſe Species. The *Eggs* of *Gnats* are of various Forms, and diſpoſed in a very beautiful and wondrous Manner in the Water, for the moſt part, ſome among the fine Moſs on the Sides of Walls, and others in other Places. Thoſe in the Water exclude a ſmall Animal, of an odd and ridiculous Form: From this we have a ſecond Metamorphoſis into an Animal of an hideous Shape, and makes the merrieſt Figure in the

Microſcope. Both theſe riſe in great Numbers to the Surface of ſtagnant Water, and the former ever hangs in an inverted Poſture, with its Head downwards; from the latter, at mature Age, proceeds the infant Gnat, by ſlow Degrees, in a perpendicular Manner, with its Head upwards; in a ſhort Time after its Excluſion it finds its Legs, and then its Wings; flutters on the Surface of the Water a while, and then attempts its Flight in the new but natural Element, the Air. The Gnat which is bred from the *Chryſalis* in the Wall, is a moſt delicate, but ſeemingly a very fooliſh or ſhiftleſs Creature; for as ſoon as they are hatch'd they fly to ſome near adjacent Place, and there they ſtay as long as you can have Patience to obſerve 'em, without ever moving from the firſt Place for many Days together.

THE *Ephemeron Fly* is of the Gnat-kind; and is, perhaps, as great a Curioſity as any in Nature. It takes its Name from the ſhort Duration of its Life, which is but the Space of *one Day* at moſt, and ordinarily not above 6, 10, or 15 Hours, as I have found by ſufficient Experience. They are bred from Eggs laid on the Surface of Water; from theſe Eggs are firſt produced a ſmall long red Worm, which flings itſelf along in the Water in the Form of the Letter S, and by that means has a Motion peculiar to itſelf. The Make of this Worm is very curious; when it has arrived to its mature State, it makes itſelf a *Theca*, or Caſe, in the Mud at the Bottom of the Water, the Top of which is open, where they put out their Heads, and thus they continue 'till the Time of Metamorphoſis, when they are changed into an incomparable fine Animal like a Fiſh, which at its full Growth is about half an Inch long; this Animalcule is too curious and ſingular in all its Parts to be here deſcribed, nor will any Method be ſufficient to repreſent it but the Microſcope. From this Creature at laſt is produced the *Ephemeron Fly* or *Gnat*, which is the moſt delicate and beautiful of all this Claſs; it is bred or hatch'd about Six in the Evening; they friſk about a few Hours on the Surface of the Water, engender,

der, lay their Eggs, grow old, and dye, generally before Six the next Morning. I have often tried, but could never above once keep one of them alive Forty-eight Hours.

The *Cricket-kind* has many Subjects worth our Obſervation. The *Gryllotalpa* or Mole-Cricket is the firſt of this Tribe, and is matchleſs in regard both of its amphigeneous Nature and Form, and the Beauty of its Parts, as they appear thro' the Microſcope. The *Graſshopper* is another Inſect of this kind; every Part of which makes a fit Subject for the Microſcope, eſpecially in the large green Sort, where the Legs beautifully colour'd, and ſet with ſharp Spines, are a very pretty Spectacle. This Creature in its Nympha-State within the white Froth, which it emits all around, is alſo a very curious Object to view. Of this Sort alſo are thoſe cantillating Domeſticks we call *Crickets*, which harbour in our Chimneys. The *Locuſts* are the Head of this Species; but as they are not to be come at in our Country, 'tis to no Purpoſe to take further Notice of 'em here.

The *Scarabæi*, or Beetle-kind, ſubdivides into various Species, of which the Principal is the great Stag-Fly; the Eyes of this Creature, its Horns, the Surface of its Head and Body, its Wings, and Legs, and Claws, are all proper Subjects to employ the curious Eye. And alſo the internal Parts, which appear upon Diſſection. In the common *Black-Beetle* nothing can equal the noble Mazarine Dye of the Thighs, and the delicate Form of their Feet; the *Antennæ* in ſome of theſe are of a curious Structure, I need only inſtance in thoſe of the common *Chafer*, which I would recommend to the View of the inquiſitive Reader. The *Lady-Bird*, or *Lady-Cow*, is alſo of this Claſs; whoſe Spots and other Accidents, make it the Subject of the Microſcope. The *Ear-Wig* is remarkable for the *Forceps* or Pinchers in its Tail, which muſt appear very formidable to the Eyes of thoſe Creatures which ſee 'em much larger than we can do by the Microſcope.

Of the *Louſe-kind*, the moſt notable are thoſe we call *Ticks*, which however loathſome or diſagreeable they are to the naked Eye, they make a very pleaſant and admirable Appearance in the Microſcope. The *Lice* which infeſt the Bodies of moſt Animals are worthy our Inſpection; particularly that *Opprobrium* of our own Species, that contemptible little Animal, which crawls ſo intrepidly over our Bodies, and riots in our Blood, when view'd by the Microſcope gives more Pleaſure than ever it did Pain before; and when we view well every Part of its Body we muſt neceſſarily have a different Opinion both of it and ourſelves than what we conceiv'd before. The *Knits* which ſtick on the Hair, are the Eggs of theſe Creatures; and make a pretty Microſcopic Object. The *Flea* is not indeed of the *Louſe-kind*, properly ſpeaking; but being near Neighbours, and Meſs-mates, they may be rank'd together: The Flea makes as odd and ſurprizing a *Phænomenon* in the Microſcope, as it is ſingular in its Nature and Form. The *Death-Watch* (I mean the moſt common Sort) is of this Tribe; in common Appearance they very much reſemble Lice, and are always found amongſt Duſt behind Picture Frames, and in old Books: they are a very pretty Object when view'd in the Microſcope. The other Sort of *Death-Watch*, is a little brown Inſect, which make and harbour in thoſe little Holes we obſerve in the Wood of our Window Boards, Frames, *&c.* The *Mites* belong to this Claſs; and are a Subject of which we can form no Idea but by the Microſcope, for by reaſon of their ſmallneſs they elude the common Sight; but this way they appear to be a moſt beautiful, briſk, and nimble Animal, arm'd with ſharp Spines all over their Bodies; and, when thoſe which are found in Meal or Cheeſe are view'd, they make a very diverting Object, as they appear in living Heaps crawling and tumbling over one another. As for the Lice on Plants they are properly of the Fly-kind in their mature or laſt State; but both theſe ſmall Flies, and their Lice-like *Nymphæ* are in their ſeveral Kinds curious Objects for the Microſcope.

THE *Spider-Genus* affords a rich Variety of Subjects, both in regard of the *numerous Species*, as well as the *peculiar Structure of Parts*, in each Individual. The large *Garden-Spider* is finely beautified with Colours, which make that Sort of Hair wherewith they are cover'd, have a very grand and noble Look. The ſmaller Sort of *Garden* or rather *Wall-Spider* is alſo richly variegated with Colours: And the very ſmall *Red Spider* is a moſt delightful Object, when view'd by the Microſcope. The large *Green* and *Yellow Spider* (found in the Fields) are worth obſerving. The *Eyes* of *Spiders* are a peculiar *Phænomenon*; in ſome you view *two*, in others *four*, in others *eight* Eyes, as in moſt of the very large *Houſe-Spiders*; when well magnified, they look as large as Sloes, and are perfectly round, and of a ſhining jetty black; ſituated very prominently, in two Ranks, in the upper Part of the Head. The Eyes in Spiders being ſmall and immoveable, is the Reaſon why they are furniſh'd with ſo many, for by this Means they have a keen Sight, and command the whole Hemiſphere about 'em. The *Mouths* of *Spiders* are furniſh'd with an horrible *Apparatus* of Inſtruments, by which they readily ſeize on, and devour their Prey. To view one of theſe Creatures, ſucking the Blood of a poor Victim-Fly, with a Microſcope, is at once both a diverting and ſhocking Sight. The hairy Legs and ſharp Talons or Claws in Spiders, are a pretty Sight, eſpecially thoſe very long ones of the *Shepherd*, or *Carter*, which indeed is a wondrous Creature all over, as any one muſt confeſs who has view'd it. The little Tubercles about the Tail of the Spider, from whence they ſpin their Web, are evident by the Microſcope; and to ſee them exert their *Textrine Art* with this Inſtrument, will give you the higheſt Satisfaction. Nor is that Web itſelf in ſome Species of Spiders, a trivial Object; but will preſent you with the Appearance of a fine Thread or String of Beads. The *Exuviæ*, or Skins which the Spiders caſt, are a Curioſity worth our preſerving. And a Neſt of *Spiders Eggs*, and eſpecially the young ones, when juſt hatch'd, are a moſt entertaining Sight in the Microſcope.

THE *Emmet* or *Piſmire* is a Creature of the Inſect-kind; and when it is ſeen by a Microſcope that will take in the whole, it makes ſuch an awkward comical Figure, that a Perſon who beholds it, and can forbear laughing, muſt be a Man of great Equanimity indeed.

AMONG the *Aquatic* or *Water-Inſects*; there are many Sorts of Water Gnats which play on the Surface, and a great Variety of large and curious Inſects which live wholly in that Element, that are exceedingly well worthy our Obſervation and Inſpection with the Microſcope. The beſt Way to catch 'em is to turn a Piece of Wire in the Form of a Ring about three or four Inches Diameter, and to ſtick one End into the End of a Cane or Staff, then putting a Piece of fine Linen over it to hang down with a Bag like a Net, you may with this Inſtrument take any Animal you can ſee in the Water, and by this Means acquire as great a Variety, as you can find on the Land; and ſome Objects whoſe Parts are more different, and more ſurprizingly diſpoſed, than can well be imagined by any one who has not ſurvey'd the watry Tribe.

CHAP. XII.

Of Microſcopic Objects *ariſing from the* Reptile *and* Serpent Kinds.

BY REPTILES I mean all thoſe Animals which move by *creeping*, *crawling*, or *hopping along on many ſmall Feet*. A *Reptile* being ſo call'd from *Repo*, *(reptum,)* to creep or crawl along.

And by Serpents I underſtand all that inſinuate themſelves along or move forward without Feet. As Adders, Snakes, Slow-Worms, *&c.*[*]

Of the *Reptile Genus* there are many Species, both on Land and Water, and moſt of them without a Name. I ſhall take Notice of ſome of the Principal which are more immediately the Subject of the Microſcope.

The *Millepede-kind* make here the firſt Claſs; among which the large *Centipede* brought from *India*, is an extraordinary Subject, if we regard the Eyes, the large *Forceps* or Pincers on its Head, its long pointed Body, and its numerous Feet and Claws. Somewhat like this in Form, is that long ſlender nimble Worm found at the Roots of Trees and Flowers in digging of Gardens; as alſo one of the *Noctiluca-kind*, or thoſe Animals that ſhine by Night. If either of theſe Animals be taken alive, and placed under the Concave Glaſs, ſo that they may have Room to move, and then view'd with the Microſcope, 'twill be very ſurprizing to ſee that orderly yet confuſed Motion of all the little Legs on each Side the Body.

The common *Noctiluca*, or *Glow-worm*, is a proper Subject for the Microſcope, for if it be view'd with the leaſt Magnifier in the Luminous Part while ſhining, you will perceive a faint, ſtill Glare, inclining to a bluiſh Colour, which this Creature can make to appear or diſappear at Pleaſure: The Head, Eyes, Legs, and other Parts of this Reptile are likewiſe worth obſerving.

The *Cheſs-Bug*, or *Wood-Louſe*, is a Creature of a curious Make or Structure, as will appear if you take a View of its variegated Coat of plated Armour, in ſome of the larger and more beautiful Sort.

The *Grub-kind* is very extenſive; I mean the various Sorts of

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[*] Thus *Serpent* is derived of *Serpo*, (*Serpens*,) *to creep*, *to ſlide along on the Belly.* And indeed both *Serpo* and *Repo* (by a *Metatheſis*) are form'd of the *Greek* ἕρπω, *to creep*, or *crawl along*.

Maggots hatch'd from the Eggs of Inſects depoſited in the Earth, rotten Trees, *&c.* among which the inquiſitive Virtuoſo will find many entertaining Subjects, when view'd with the Microſcope, though generally eſteem'd ſo very diſagreeable a Spectacle to the naked Eye.

THE *Caterpiller-kind* are undoubtedly the moſt *ſingular*, *delicate*, and *gaudy* Part of the animal Creation. Nor does any Species of living Creatures regale the Eye with a more delightful Variety of Peculiarities; ſome are exceeding glabrous and ſmooth; others richly ornamented with delicate Tufts of Hair of various Dyes and Colours; others ſurprizingly bracteated with brillant Protuberancies or Spangles all over their Bodies. To view their numerous Claws in each ſhort broad Foot; their painted, poliſh'd, ſpangled, hairy Bodies; their Eyes and Mouth, and the Manner of their feeding on Leaves; the Web or Silk which they ſpin, and the curious Manner in which they diſpoſe it with their Mouths; and laſtly, the various Forms and beautiful Colour and Tints of the *Aureliæ* into which they are transform'd for their laſt Change, are all of them ſuch Arguments of infinite Wiſdom, Deſign, and Providence, that I would recommend them not ſo much to the *Curioſo* for his Delight, as to the *Atheiſt* for his Conviction and full Satisfaction of the Exiſtence of a Deity.

THE *Cados-Worm*, *Cod-Baits*, *Straw-Worms*, and all the *Phryganean* Tribe, which make themſelves *Thecæ* of Straw, Pebbles, Sticks, ſmall Snag-Shells, *&c.* are, both themſelves and their *Thecæ* or Caſes, very proper Subjects for the Microſcope. And more eſpecially a ſmall Land-Animal of this Sort, which are found in great Plenty crawling on Fruit-Trees or Walls, with their *Thecæ* almoſt perpendicular, about the Size of a Barley Corn. To view the Form of this Creature, the moſt curious Compoſition of its *Theca*, while it is crawling under the Concave-Glaſs, is a *Phænomenon* to the laſt Degree entertaining and delightful.

THERE are various other Animals of the *Reptile-kind*, which the curious Enquirer will find on every Spot; but as they have no particular Names, nor are reducible to any general Claſs or Species, I am obliged to paſs them by, and ſhall next proceed to the Principal Objects among

THE *Serpent-kind*, or thoſe which crawl on their Bellies without Legs or Feet. Of theſe the moſt remarkable is the *Viper* or *Adder*; in which we view the *various colour'd Scales* which cover its Body, in the *Exuviæ* or old caſt Skin; its Eyes, its forked Tongue and Teeth, among which we obſerve that peculiar Tooth or Fang, thro' which in the Bite diſtills that deadly Drop, for which thoſe Creatures are ſo terrible, and often fatal, to Mankind. The Uſe of the Microſcope in diſſecting this Animal is every Way very great, as may be ſeen in Dr. *Mead*'s Eſſay on Poyſon, and others who are refer'd to in that Book.

IN the ſame Manner we may examine and take a View of the ſeveral Parts of the *Snake* and the *Slow-Worm*, both external and internal; and not without the greateſt Pleaſure and Improvement of the Mind, to thoſe who are delighted with the Knowledge of the different Methods, and infinite Variety of Nature in the Structure of Animal Bodies.

THE *Earth-Worms* are another Claſs of the *Serpentine-kind*; of theſe there are divers Sorts. They alſo caſt their Skins, which being ſo exceeding fine and tranſparent, are ſeldom to be found, but when they are, make an extraordinary Subject for the Microſcope; as do alſo the very fine Scales which make them feel ſo rough to the Hand drawn from the Tail towards the Head. The *Mouths* of theſe Animals are only diſcoverable by the Microſcope. The *Viſcera* and Inteſtines of Worms are worthy our Inſpection, and their *Dung* or Excrement, both *moiſt* and *dry*, for Reaſons which will then be apparent.

THE *Snails* are a notable Species of this creeping Kind. Their *Shells* are many of them beautifully embelliſh'd and variegated with Colours, and curiouſly wrought. The Eyes of *Snails* are a re-

markable

markable Oddity, they are ſeated on the tops of their large Horns, by which means they can be drawn into the Head or thruſt out at Pleaſure. Their *Teeth* are another Microſcopic Object, and it is very pretty to ſee 'em feed on Leaves, *&c.* with this Inſtrument. This Animal is *Hermaphrodite*, and the *Parts of Generation* are in the Neck, which *in Coitu* are eaſily examined by the Microſcope. The *Eggs* of Snails are round and white, and, when hatch'd, the young tender Brood make a very pretty Scene in the Microſcopic Theatre.

C H A P. XIII.

Of Microſcopic Objects *ariſing from* Plants *and* Vegetables.

THO' a great deal has been ſaid, and Volumes wrote on the Subject of PLANTS and VEGETABLES, little worth our Notice has been diſcover'd in their Nature, Parts and Texture, 'till the Uſe of the Microſcope was applied to that Purpoſe. Since that Time Philoſophy, in this Part, has received the greateſt Improvement; and 'tis ſurprizing to conſider in how ſhort a Time, by this Means the Oeconomy of Nature in the various Proceſſes and Gradations of Vegetation has been moſt accurately detected, and expoſed to the View of Mankind.

FOR upon a Microſcopic View and *Examen* of the *Cortex*, or *Bark* of Trees, we find it to conſiſt of *Lignous Fibres* implicated in a retiform Manner, the Interſtices of which are fill'd with *Utriculi* or little Bags or Bladders turgid with Juice; which, when they pour out, become flaccid, and make a fine dry Skin or Membrane,

brane, which is eaſy to be obſerv'd in the Rinds of the *Plumb-Tree*, *Cherry-Tree*, *Beach*, &c.

THE *Lignous Fibres* lye in ſeveral *Strata* one upon another, and their Intervals diminiſh as they approach the Trunk; they conſiſt of numerous hollow *Fibrillæ*, or Threads, which contain a Liquor that paſſes thro' them in a Sort of Circulation. The Orifices of theſe Sap Veſſels are plainly to be ſeen in a tranſverſe Section of ſome Cortices; and the *Utriculi* or ſmall Globular Bladders in thin Slices of Cork, make as pretty an Appearance as as any thing, perhaps, that is view'd in the Microſcope.

THE *Stem* or *Trunk* of Trees, when view'd in a tranſverſe Section, appear alſo to conſiſt of vaſcular Parts, or hollow Fibres; and a *Parenchyma* of Utricles, which fill up their Intervals. Thus if a Vine Branch be ſo cut into thin Slices, you will ſee a moſt beautiful Appearance of Orifices of Veſſels, and Fibres, and Utricles all tending to, or rather radiating from, the Center or Pith, which you will eaſily perceive conſiſts of an infinite Number of fine tranſparent Bladders, particularly if it be that of Elder, or ſuch like Wood.

THE *Lignous Fibres* and Veſſels lye in various Directions, ſome perpendicular, others horizontal, and others run obliquely. Theſe perpendicular and horizontal Fibres lying *Stratum ſuper Stratum*, make the Appearance of a moſt curious Texture, or *Web* of *Warp* and *Woof*; as is moſt viſible in a Piece of *Fir* or *Deal*; or in a Piece of *Touch-Wood* rightly ſplit, eſpecially that taken from a rotten *Elm-Tree*.

AMONG theſe hollow Fibres ſome grow in a *ſpiral Form*, like the Worm of a common *Bottle-Screw*; theſe are larger, and leſs numerous than the reſt; they are ſuppoſed to be the *Tracheæ* or Air-Veſſels in Plants. Theſe ſpiral Fibres are moſt eaſily view'd in the Foot of a Vine-Leaf, carefully broken while ſucculent or full of Juice; for then if a Microſcope be applied to the Fracture, there will be ſeen thoſe ſpiral Fibres going from one Part to the other, more or leſs drawn out or uncoil'd; and not only one but ſeveral of them, which make a moſt delightful View.

THE Structure of the Roots of Plants and Trees is nearly the ſame with that of their Stems or Trunks: conſiſting of *Sap* and *Air* Veſſels, with a *Parenchyma* of Utricles; but in this Part we ſee no Pith; and tho' the Root be that Part which ſucks in the nutricious Juices for Vegetation, yet are the Orifices of the Veſſels too ſmall to be ſeen by the beſt of Microſcopes: But the Veſſels themſelves in the Body of the Root are more diſcernible than in the Trunk, if we cut it tranſverſely into thin Slices; and for this Purpoſe, the Elm-Root is the moſt eligible among Trees, and the Root of Fern among Plants is the moſt beautiful Sight that can be ſeen of this kind if cut in the thickeſt Part, and view'd when dry.

THE *Gems* or *Buds* of Trees are a noble Subject for the Microſcope; for they afford a particular Pleaſure if analyſed with this Inſtrument, by viewing the various Forms and Colours of the *Involucra* or external Coverings, which in ſome are ſmooth, in others downy, and like Scales lye one upon another, within which is contain'd the tender Branch, whoſe ſeveral Twigs and Leaves, if carefully unfolded, may be eaſily ſeen in Miniature. The *Gems* of Flowers in Fruit-Trees, when open'd, diſcover a curious Proſpect in the ſquamous Leaves of the *Involucrum*, border'd with pearly Globules, or nicely ſerrated with regular Denticles; and under theſe appear the delicate Flower folded up, yet all its Parts diſtinct and viſible: And laſtly the Embryo-Fruit, which if cut aſunder ſhews all its Parts duly form'd, only in ſmall, and in a juicy or *fœtal* State, which is afterward maturated by Age.

THE *Leaves* of Trees are the Subject of the Microſcope throughout; for in regard of their Surfaces, we obſerve in many of them a curious *Phænomenon* of Adjuncts or Increſcences, in various Shapes and Colours; as of pellucid aqueous Globules in *Mints*, *Hyſſop*, *Pennyroyal*, *&c.* of opake, white, waxen Balls, or *Pilulæ*, in thoſe of *Sage*; of pearly Drops in *Spinage*, eſpecially wild Spinage; thus the Leaves of Hops are nobly imboſſed with golden Studs: And, finally, the Surfaces of *Sow-thiſtle Leaves* are curiouſly decorated with innumerable Strings of Bead-like Bodies; not to mention various others which the *Virtuoſo* will find in ſeveral other Plants.

If *Leaves* are ſteep'd in Water for Maceration, the Pellicle or thin Skin of both Sides will eaſily peel off, which laid on a Glaſs and view'd with the Light reflected thro' them, will diſcover a moſt delicate Texture in fine diaphanous Membranes of Net-work; as may be ſeen in thoſe of *Oak*, *Maple*, *Holly*, *Walnut*, *Orange*, and all the Evergreens. But as for the Pores which ſome have pretended to have diſcover'd, I never could by any Means attain to the Sight of them in any Subject I have examined.

Between theſe two Skins is contain'd the Parenchymous Subſtance of the Leaf, which appears to conſiſt of an infinite Number of Utricles, or little pellucid Bags of a green Liquor or Juice, which are all implicated or contain'd in an internal fine Membrane, which is extended thro' the whole Leaf between the *Areolæ* of the Lignous Fibres. This may be examined in all the groſſer Leaves; as of the Fig-Tree, *&c.*

The lignous or fibrous Part of the Leaf, when diveſted of all the *Parenchyma* by Maceration in Water, makes a moſt beautiful Spectacle, conſiſting of a large Body or Stem in the Middle, with a great Number of Collateral Branches iſſuing from either Side, which again are moſt minutely ramified into numberleſs *Fibrillæ* intervening and inoſculating with each other towards the Extremities, ſo as to form a Texture exceeding the richeſt and moſt exquiſite Piece of Lace-Work ever yet ſeen. And what is moſt remarkable, is, that this Skeleton of lignous Fibres is compoſed of two Layers or Courſes of Fibres, ſuperpoſited one upon the other, and are eaſily divided or ſeparated from each other throughout, by Maceration, by a dextrous and experienc'd Hand, eſpecially in the *Holly-Leaf*, or, which is much finer, the *Apple-Leaf*. Theſe are ſuppoſed to be analogous to the Syſtem of Arteries and Veins in the human Body, which conſtantly accompany each other thro' all their Infinity of Ramifications, tho' not ſo unitedly as in this Caſe of Plants.

THE broad long Leaves or Blades of Graſs, Corn, and annual Plants, as Onions, Leeks, *&c.* if inſpected in the aforeſaid Manner by the Microſcope, will afford Entertainment enough to the ingenious Naturaliſt. To obſerve the *Aculeoli*, or ſpinous Stings of Nettle; the uncated Tenters, or Hooks of Clivers; the ſcarlet or crimſon *Aciculæ* or Pin-like *Stamina* on the Foot-Stalks of the Leaves of the Filbert-Tree, *&c.* with the various colour'd *Lanugo*, Down, Hairs, *&c.* obſervable on many kind of Plants, are Topics of the fineſt philoſophical Amuſement.

THE *Flower in Plants* is the next Part which offers itſelf to the Microſcopic Eye; here Nature exuberates in Gaiety and Variety, and ſeems oſtentatious of Contrivance and Deſign. How noble, how rich, how delicate, is the whole Compoſure of every Flower! How various, deep, and bold, are the Colours of the Leaves! How delicate the Attire of tender *Stamina*, with Heads of a *Seminiform* Matter or Duſt, which appear perfect Globules in all the Degrees of Miniature! Theſe are largeſt and very beautiful in the *Marſhmallow Flower*, the *Tulip*, *Lilly*, &c. The *Stylus* is often of a curious Shape on the Top, it is ſuppoſed to be hollow in all Flowers, ſerving as a *Vagina* to receive the Semen or Duſt of the Apices of the *Stamina*, and to convey it to the *Matrix*, or Fruit, which, as *in Utero*, contain the true Seed or Kernel from whence the Plants proceed. This is the Theory of the Generation of Plants and Trees; which, as in that of Animals, is of ſuch a Sort, that having proved one Part, we are obliged to ſuppoſe the other.

THE *Fruit of Plants* is contrived with infinite Variety for the Uſe abovemention'd; 'tis impoſſible to take Notice of every Part here that well deſerves our Regard and Inſpection by the Microſcope. I ſhall only juſt remark, that the ſucculent pulpy Part in Apples, Gooſeberries, Cherries, &c. if cut into very thin Slices, and laid under the Microſcope, will diſcover a fine Contexture or Branchery of fibrous or vaſcular Parts, whoſe Interſtices are fill'd with Utricles of Juice, in many, ſo delightful to the Taſte: And alſo that the Kernel does conſiſt of an infinite Number of round or ſpheroidical Corpuſcles, which alſo compoſe the Subſtance of all Kinds of Pulſe, as Beans, Peaſe, *&c.* Theſe are evidently ſeen if a Bean, for inſtance, when boil'd, be gently rubb'd on a Glaſs, and then laid under the Microſcope. In the laſt Place, a great Curioſity it is to view the future Plant in the preſent Fruit, compleat in every Reſpect, even while it is yet in the Pod, or Shell. This may be very eaſily obſerv'd in the larger Sort of Garden and Kidney Beans, and in the Fruit of divers Plants and Trees.

THE ſmall *Seeds* of Plants and Vegetables of the leſſer Species, are a copious Subject for the Microſcope; particularly that of *Fern*, which grows in ſmall *Heads* on the underſide of the Leaves round the Edges; theſe are of the ſame kind with thoſe which grow on the Leaves of Hart's-Tongue, which when ripe, and rubb'd on a Glaſs, will diſcloſe and ſhed abundance of ſmall Seed like Duſt, but when view'd with the Microſcope appear perfectly round, and ſo ſmall that Millions grow on a Leaf. Theſe pulverulent Seeds grow in a ſomewhat different Form on the Leaves of *Hart's-Tongue*, and the Maiden-Hairs; in which latter Plant they are of ſuch a curious and peculiar Form, that you would be apt to miſtake 'em for a beautiful ſmall Sort of Caterpillar, were you not told beforehand what they were and whence.

THE ſeveral Sorts of Moſſes will employ the leiſure Hours of the Microſcopic Virtuoſo to very good Purpoſe; as alſo the various Species of *Muſhrooms*, *Puff-Balls*, *Truffles*, *&c.* The Excreſcences of Trees, particularly that *Fungus* we call *Jew's Ear*, is a very pretty Phænomenon in the Microſcope.

THE *Flower* of Graſs and Corn; the *Beard* of *Wheat*, *Rye*, and eſpecially *Barley*; the *Iuli*, or Catkins of *Haſle*, *Willow*, *&c.* with a thouſand other Adjuncts, will offer themſelves to the View and Admiration of any one who ſhall undertake to reconnoitre the numberleſs Curioſities of Vegetables.

CHAP. XIV.

Of various Microſcopic Objects *not reducible to the foregoing Claſſes.*

I SHALL begin this miſcellaneous Account of Microſcopic Objects with thoſe *Animalculæ* which are to be found in Water, wherein Pepper, Fleſh, Leaves, or any other Subſtance has been ſteep'd for ſome Days in the Summer-Sun.

THE firſt and moſt remarkable of theſe is the *Monoculus*, or one-eyed Animalcule, which will be found in great Numbers in every Puddle towards the latter End of the Summer. They are of an odd but curious Form, with one black Eye in the Middle of the Head, and are tranſparent, inſomuch that ſix or ſeven young ones are often to be ſeen in the Body of the old ones. A good Cut of this Creature Mr. *Bradley* has given in his *Survey of the Works of Nature*.

ANOTHER very remarkable Species have Shells of the Bivalve Kind, ſomewhat like a Muſcle; 'tis very pleaſant to ſee how nimbly they move, and with what Agility they work their fine Legs and Limbs, when the Shell is open. Of theſe there ſeems to be ſeveral Sorts; ſome are as large as great Pins Heads, and others ſo ſmall as ſcarce to be diſcern'd with the Microſcope; ſome round, others oblong; ſome green, others brown, and others almoſt white.

There is another moſt beautiful Sort of Animalcule, which can't be well deſcribed, but in this Particular that it bears its Sperm in two Cluſters on its Tail, like two Bunches of Grapes; one Sort has but one of thoſe ſpermatic Cluſters of Eggs. The Reader will be beſt ſatisfied in viewing it; or he may ſee the Figure of it among ſeveral which Mr. *Lewenhoeck* has given in the *Philoſophical Tranſactions.*

There is another Sort of *Animalculæ* which have neither Shells nor Legs, but ſeem to be of the Maggot-kind, they are of an oblong Form, which they greatly vary in their Motion; they are in prodigious Numbers in prepar'd Water, and move with great Celerity confuſedly among eachother; they grow from a ſmall to a larger Size; *viz.* about the 10th of an Inch long. They have a ſurprizing Tenacity of Life; for I have put 'em in a Glaſs Tube in a freezing Mixture, where they have remain'd frozen in the Ice for an Hour and more; yet upon thawing the ſame, thoſe which were not torn aſunder by the Extenſion of the Ice, ſoon recover'd Life and Motion, and were as well, to Appearance, as before.

Among theſe ſmall Creatures I have ſometimes obſerved a Sort of Spider, at leaſt, a ſmall Creature like one, with a little Body and ſeveral Legs proceeding from each Side; but theſe are not very numerous, nor often to be obſerv'd.

Another kind of *Animalculæ* appear like ſo many *Veſiculæ* or little Bladders, tumbling and wavering about in a very odd Manner; they are not perfectly round; have neither Head, Tail, nor Legs which one can diſtinguiſh, nor are they tranſparent, nor quite opake. Theſe Characters I believe will convince the Reader when he ſees the Animal I mean.

The laſt Species of theſe Animalcules I ſhall mention, are the moſt wonderful and ſurprizing of all, in regard of their Number and Minuteneſs; for they appear but as Points thro' the largeſt Magnifier: They make that Scum or thin Spume we often obſerve on the Surface of ſtagnant Waters of a greeniſh Colour, ſometimes of a yellowiſh, and ſometimes of a bluiſh Hue. If a Piece of Glaſs be carefully put under it to take up a Part, and then laid under the Microſcope and ſtrongly illuminated, you will perceive an infinite Number of living moving Points, as it were; they are of a roundiſh Figure, and nearly as ſmall as thoſe in *Semine Maſculino*. They appear all at once on the Surface of the Water, and almoſt as ſuddenly diſappear; and what becomes of 'em, I believe he only knows who at firſt gave them being. However they are conjectured to be the Nympha State of ſome ſmall Inſects which fly inviſible in the Air, which lay their Eggs on the Water, as the the Gnat-kind are known to do.

IN *Vinegar* there is another Sort of *Animalculæ*, which is of the *Anguicular* or *Eel-kind*; for they differ in nothing but Fins from the Form of Eels that I could ever obſerve: They are not to be found in all Vinegar, but chiefly that which is ſtale, and the laſt Run of the Caſk. They are often ſo large as to be ſeen with the naked Eye. The beſt way to get a great many in a little Compaſs is to take a Quantity of that Vinegar in which they are found, and filter it thro' a Piece of Paper to as ſmall a Quantity as you deſire, and then putting it under the Microſcope, you will have a moſt entertaining Sight of thoſe curious little Creatures, which will now look large, and reſemble thoſe in our larger Ponds.

I have found theſe *Anguiculæ* likewiſe in the Water which ſtands in the Cavities of *Cow-Dung* after a Shower of Rain; and I find others have ſeen them in mouldy Paſte; but I confeſs I never could, tho' I have often ſought after them in that Subſtance. I have likewiſe very carefully, and often examined Blood, Milk, Urine, and other animal Fluids, but could never ſee the leaſt Appearance of an Animal in any of them, but the *Semen*; tho' I know ſome have aſſerted they have. The ſame I can ſay of all fermented Liquors, as Wine, Beer, Cyder, &c.

If while you are viewing theſe *Animalculæ* you let fall a ſmall Drop of any Spirit, as Brandy, into the Water, you will perceive they will be greatly diſturbed, and ſoon become motionleſs and die, which plainly proves that Water is their only Element to live in.

CHAP. XV.

Of Miſcellaneous Subjects *for the* Microſcope.

I SHALL here treat of thoſe Subjects which could not well be reduced to any of the foregoing Claſſes; and as they are heterogeneous and independent of each other, I ſhall pen them down juſt as they occur, without any regard to Order; and firſt, among theſe, is

Sponge; this is a ſubmarine Plant or Moſs, which upon being view'd in the Microſcope, will diſcover ſuch a Compoſition and Texture of Parts, as are equally full of Wonder and Entertainment. There are many other Productions of this Sort to be found in the *Muſeums* of the Curious, well worth our Inſpection by the Microſcope.

Sea-Water evaporated on a Piece of Glaſs over a gentle Fire, and laid under the Microſcope, will preſent you a clear View of the Particles which compoſe our common Salt, in their ſimple natural State, whence you'll be able to form a true Notion of their Figure, Size, &c.

Also the Ashes of any Wood or Plant being ſome Time ſteep'd in Water, will communicate its Salt to the Lye; a little of which evaporated, as before, will ſhew the peculiar Figure of the Salts of that Plant; and by this Means you will obtain a great Variety of Vegetable Salts. The ſeveral Figures and Forms in which they are diſpoſed in the Fibres of Plants, you may ſee in Dr. *Grew*'s *Anatomy of Plants*.

A Piece of any Sort of fine *Linnen*, *Silk*, *Ribbon*, *&c.* looks ſo coarſe and comically, that it never fails of making a very agreeable and merry Subject for the Microſcope.

Sand when thus view'd, appears like an Heap of Stones or Cryſtal; for they are, for the moſt Part, tranſparent; but ſome are opake: They conſiſt of poliſh'd Surfaces, and many ſharp or pointed Angles in general, on which Account they make a very pretty Spectacle, when the Light is reflected among them eſpecially.

To view the *Edges* of *Pen-knives* and *Razors*, and ſee how jagged and ſerrated they are; or the Points of the ſharpeſt and fineſt *Pins* or *Needles*, and obſerve how coarſe and rugged they are; or laſtly, to view the moſt poliſh'd Surfaces, as thoſe of Reflecting Mirrours, and ſee the innumerable Pores, the Scratches and Strokes of the Putty, *&c.* never fail to excite Admiration and Surprize. In natural Objects, the Politure is heighten'd the more, the more they are magnified; and in all Caſes, the more intimately we can approach Nature, the more perfectly her Works appear; quite contrary to what happens in all the Effects of Art, as is very evident by the Microſcope.

If in *ſtriking Fire* with a *Flint and Steel*, the Sparkles are caught in a Piece of Paper folded up, and then placed under the Microſcope, they will appear as ſo many *Iron Bullets*, being perfectly round; which Form they receive from the Particles of Steel being melted by Ignition, and cooling ſo ſuddenly in the Air, muſt neceſſarily conform to a ſpherical Figure.

The *Teeth* of a *Raſp* or *File*, of the finer Sort, are worth our View; we ſhall no longer wonder at their Effects in working on Braſs or Iron, when once we behold 'em in a Microſcope.

If a Piece of *Steel* be broke, and view'd on the fractured End, the Particles of the *Steel* will look exceeding bright and beautiful, yea they ſhine with ſuch a Luſtre and *Eclat*, as make them reſemble precious Stones.

Snow is a Meteor wherein Nature ſeems to obſerve the ſtricteſt Rules of Geometry; every ſimple original Particle of Snow conſiſts of a central Part with ſix *Radii* proceeding from the ſame at equal Angles, which Angles are therefore each 60 Degrees; the central Part is in moſt a regular *Hexagon*. Each of the *Radii* is richly embelliſh'd with a Sort of Foliage or *Pinnulæ*; and each *Pinnula* variouſly laciniated, like a Branch of Fern. So that each Particle of *Snow* makes a moſt rich and beautiful Figure in the Microſcope, far beyond what can be ſuppoſed by any who have not ſeen them.

The *Froſt* on Glaſs Windows is a wonderous Piece of Natural Tapeſtry in the vegetable Way. The finer and more delicate Parts thereof appear thro' a Microſcope ſo noble and exquiſitely fine, that nothing can compare with it in all the Works of Art. The Froſt alſo on the Leaves of Plants makes a glorious Figure; and ſome Sorts ſeem to have a kind of Vegetation, which ſhoot into Leaves, and Stems, on the Tops whereof grow hollow Cups, of ſix Sides and Angles, all equal and regular. With ſeveral other *Phænomena* peculiar to or reſembling the vegetable Kind.

Various Sorts of *Stones*, *Foſſils*, *Marcaſites*, *&c.* when broken, exhibit very curious Appearances in the Microſcope: Alſo ſeveral Sorts of Drugs, and Chemical Preparations; as *Phoſphorus*, *&c.* deſerve a Microſcopical Examination.

Any ſort of *Spirits*; as *Brandy*, *&c.* when placed in the

Concave under the Microſcope, will appear to have a confuſed inteſtine Motion, the Motes being driven and impell'd this way and that, in all Directions, with unequal Motion; ſometimes very rapid, then ſtopping at once, then flying backwards, and in this turbulent State it will continue till all the ſpirituous Part is eſcaped or gone off, after which the aqueous Part will remain perfectly quiet and ſtill.

If in any *Acid*, as *Vinegar*, any alkaline Subſtance be mixed, while under your View, you will perceive a great Colluctation and Effervefcence enſue, which will prove a very diverting Spectacle to the curious Beholder.

The fineſt *Paper* looks exceeding coarſe in the Microſcope, and 'tis no unpleaſing Sight to view the Impreſſion of Letters in the ſmalleſt Print or Writing. If the *Paper* be burnt, and then viewed in the Aſhes while yet entire, you will ſee moſt diſtinctly how all the Threads lay in its Compoſition by the *Stamina* which yet remain, and make a very pleaſant Spectacle.

If that which we call the *Vinew* or Mould of any Subject be view'd, it will diſcover a moſt beautiful Scene of Vegetation of a peculiar kind; there you will diſcover Fields of ſtanding Corn, *i. e. Stamina*, with globular *Apices*; and various other Plants *ſui Generis*; and you will not rarely find thoſe Fields and Meadows ſtocked with a Sort of nimble ſmall Cattle and Herds, which ſkip ſportively over the Lawns. You will alſo ſee their various Purſuits, Conteſts, and horrid Attacks and Engagements; with divers other diverting Incidents among the Inhabitants of this *Terra inviſa*, or inviſible Land.

AN

ACCOUNT

OF THE

Camera Obſcura, and the *Solar Microſcope*,

OR

METHOD of *Magnifying Objects* in a *Darken'd Chamber*,

In every Way by REFLECTION and REFRACTION.

IT may be proper in a Work of this Nature, to give a ſhort Account of the Methods of magnifying ſmall Objects in a *Camera Obſcura*, or *Darken'd Chamber*; eſpecially as it was omitted in my *Syſtem of Optics*, and is in itſelf a Matter of very great Curioſity.

THE Methods of doing this are two; the *firſt* by *Lenſes*, where the Magnified Image is form'd by refracted Rays; the *ſecond* is by *Mirrours*, where the ſaid Image is form'd by Reflection. In both Caſes the Image may be magnified to what Degree you pleaſe; and the Object though exceeding ſmall itſelf, will be beheld in that Image with equal Pleaſure and Surprize.

THE *Apparatus* for the firſt Method is as follows: (1.) The Chamber or Room is to be made as dark as poſſible; (2.) A Scioptric Ball and Socket is to be fix'd in the Hole of the Window-

Shutter, as uſual, but without its Glaſſes; (3.) A Tube is to be provided of about 2 ¼ Inches Diameter, and 5 Inches long; (4.) One End of this Tube is to be fitted in a Piece of Wood-Work, on the outer Part of which it is to be ſcrew'd into the Hole of the Ball in the Socket; (5.) And on the inner Part is placed or fix'd by a Screw, a Lens of about 2 Inches Diameter, and 3 Inches focal Diſtance; (6.) Within the other End of the Tube ſlides a ſecond Tube about 4 Inches long; (7.) At the inmoſt End of which a Piece of plain Glaſs is made to take out and in, by means of a Wood-Screw; (8.) And on the outermoſt End is fitted a Piece of Wood-work, in which is made to ſcrew a long wooden Tube of ½ an Inch Diameter, containing (9.) a ſmall Lens of about 1 ½ Inch focal Diſtance. Theſe are the ſeveral Parts of the Inſtrument; their Uſes ſeverally are as follow:

THE Object is to be extended and laid on the Piece of plain Glaſs *(Art. 7.)* with a little Size or Gum-Water to make it ſtick faſt, then ſcrew'd into its Place. The external Tube with its Lens being into the Ball in the Window-Shutter, the inner Tube with the Object is to be placed within it, at ſuch a Diſtance, that the Sun-Beams collected by the Lens *(Art. 5.)* may illumine the Object to what Degree you find neceſſary. This done, the ſmall Lens *(Art. 9.)* is to be mov'd forwards and backwards till it be well adjuſted for giving a perfect Image at the Diſtance you require it.

AND now there will be exhibited a glorious Spectacle indeed, and worthy the Attention of every *Curioſo*; provided the Object be pellucid or tranſparent; as the Wings of Flies, the Skin or Pellicles of Animals or Plants, the *Animalculæ* in Fluids; and in this Manner, that grand Curioſity, the *Circulation of the Blood*, if ſkillfully and dexterouſly managed, may be ſhewn to the greateſt Advantage in the tranſparent Tails of Tadpoles, or Efts, &c. as alſo the *Animalculæ in Semine Maſculino*, may, with proper Care, in this Way, have their Forms, Motions, &c. made evident to a moſt wonderful and amazing Degree.

THE hollow Glaſs Tube belonging to the Microſcope, will be moſt convenient for the *Animalculæ* in Water, which may be moved thro' two Holes made in the external Tube about half an Inch nearer the large Lens than its Focus; for then the Objects will be throughly enlighten'd.

IN this manner alſo very ſmall and long Objects, if not tranſparent may be magnified with a great deal of Pleaſure, as Hairs and Fibres of Fleſh; the *Antennæ*, Legs, Claws, Briſtles, *&c.* of Inſects; the Skeletons of Leaves; Sponge, and porous Bodies, as Cork, *&c.* the Beards of Corn; fine Linnen, *&c.* theſe all afford the moſt entertaining *Phænomena*.

IF the Object be large and opake, the Image of it will be diſtinctly exhibited, and well defined; ſo that it may be drawn with Eaſe; but the Images of ſuch Objects are properly Shadows only, and ſo none of the Colours can be in this Manner ſhewn.

BUT this Inconvenience may be thus remedied; inſtead of the Convex Lens *(Art.* 5.*)* you are to place a Concave Mirrour of about 1 $\frac{1}{2}$ Inch focal Diſtance on the other Side the Object, with a ſmall Hole in the Middle. The Sun Beams falling on this Mirrour will be reflected to the interior Side of the Object, which, being thus ſtrongly illuminated, will be ſhewn very diſtinct in all its Colours in the Image, which will be form'd by the ſame Object Lens placed near the Central Hole of the Mirrour.

In making this Experiment, Care muſt be taken, that the Solar Rays fall perpendicularly on the large Lens or Mirrour, ſo that they may receive the greateſt Quantity, and the Light on the Object be the ſtrongeſt poſſible. Hence it follows that the Image of Objects will be thrown on the Floor of the darken'd Room at all Times, except when the Sun is very near the Horizon, when the Rays will go nearly parallel to the Floor acroſs the Room to the oppoſite Wall where the Image will then be projected; and this can be only in the Morning or Evening.

But that this may be done at any Time of the Day, you need only ſo place a Piece of plain Looking-Glaſs on the outſide of the Socket or Window-Shutter, moveable on a Hinge, that by means of a Thread or wire Screw it may be raiſed or lower'd to ſuch a Poſition, that the Rays falling on it ſhall be reflected thro' the Hole of the Ball, and paſs parallel to the Floor, on the oppoſite Wall, where in this Manner the Image may be always repreſented more commodiouſly than on the Floor. A little Practice and Experience will make the whole Proceſs very eaſy.

The other Method of magnifying Objects in a *Dark Chamber* is very ſimple, eaſy, and moſt perfect; thus, let the Rays of the Sun come into the Room thro' a Hole in the Window-Shutter (without the Ball and Socket) about 1½ Inch Diameter: Then hold a well poliſh'd Mirrour (better of Metal than Glaſs) of 2, 3, or 4 Inches focal Diſtance, any where in the Cylinder of Rays, and an Object held in the other Hand, at a little more than the focal Diſtance of the Mirrour, will have its Image thrown on the oppoſite Part of the Room very fair and perfect; and by varying the Poſition of the Mirrour you may form the Image on any Part of the Room you pleaſe.

Instead of holding the Mirrour in your Hand, you may fix it on a ſmall Stand, and moveable in a Semicircle of Braſs which may be raiſed higher or lower as occaſion requires: And the Object may alſo be fix'd in its proper Place by a like Contrivance, ſo that the Experiment may be made in this Manner, without any Fatigue or Trouble, and will ſucceed very well if the Object be tranſparent; but if it be opake, it muſt be enlighten'd by another Mirrour and Cylinder of Rays, let in by another Hole near the firſt.

When the Room is darken'd, beſides this Method of magnifying Objects, it may be uſed for other Purpoſes very curious and important. Thus if a Lens of about 6, 8, or 10 Feet focal Diſtance, be fix'd in the Scioptric Ball, then if the Sun ſhine ſtrongly on the Objects without, oppoſite to the Window, the Images of all will be diſtinctly form'd on a Wall or large Sheet or Screen of white Paper placed in the Focus of the Glaſs; the Reſult of which will be a beautiful and moſt perfect *Piece of Perſpective*, if the Objects are Buildings, *&c.* but Gardens, Fields, Meadows, Hills, Groves, *&c.* preſent you with a moſt exquiſite and inimitable *Landſcape*.

In both the *Perſpective* and *Landſcape*, the Lights and Shadows are moſt beautifully and ſtrongly expreſs'd with all the charming Variety of Colours more vivid and intenſe than in the Objects themſelves by far; and what is peculiar to this ſort of Painting, the Motions of Objects are alſo repreſented, the Trees wave, the Leaves quiver, People walk, Birds fly, Ships ſail, Chimneys ſmoke, and every thing is Life itſelf in Miniature, and greatly heighten'd.

Another noble Experiment in the *Dark Chamber*, is exhibiting the Sun's Face, with the Spots that frequently appear thereon. Thus if the ſame Glaſs be made uſe of as before, and turn'd to the Sun, its Image will be form'd in the Focus; and if the Diſtance of the Focus be 10 or 12 Feet, the Image of the Sun will begin to ſhew the Spots, without more ado: But a much better Way is, with a Reflecting Mirrour to throw the ſaid Image very large on the Cieling, or Side of the Room, where it may be view'd without Offence to the Eyes, and the Spots will be greatly magnified and afford a moſt delightful Spectacle.

If a common Priſm be held in the Beam of Rays let into the *Dark Chamber*, they will be all ſo refracted in paſſing thro' it, as to be ſeparated into their diſtinct and proper Species, each of which Species will produce a diſtinct and vivid Colour. Theſe Species of original or homogeneous Rays are ſeven; and therefore ſeven ſtrong and lively Colours will be produced from a ſingle Beam of Light, which will make a glorious and ſurprizing *Phænomenon* on the Cieling or oppoſite Wall of the Room.

THE laſt Uſe of the *Dark Chamber* I ſhall mention, is for the Sake of the Deſigner; for if any Object be placed at double the focal Diſtance of the Lens in the Ball without Doors in the Sun, its Image will be form'd at the ſame Diſtance from the Lens in the *Darken'd Room*, and of an equal Size with the Object. If the Object be placed near or farther from the Lens, the Image will be proportionally greater or leſſer, and by this Means any Object may be drawn in any Proportion of Magnitude, which will be found extremely uſeful on many Occaſions to the practical and ingenious Artiſt.

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